Recognition of Ancient Channels and Archaeological Sites in the Mesopotamian Floodplain Using Satellite Imagery and Digital Topography

Jaafar Jotheri and Mark B. Allen

Introduction

Examination of satellite imagery and digital topography has become an increasingly important tool for geologists, geomorphologists, and archaeologists, because this method integrates information drawn from multiple sources and provides accurately calibrated physical locations (Hritz 2010; Walstra *et al.* 2013). The use of such techniques to identify palaeochannels and ancient settlements has increased in recent times, particularly in the Middle East region (e.g., Hritz 2010; Pournelle 2003; Scardozzi 2011; Ur 2013; Walstra *et al.* 2011).

Methodology

The landscape of the Mesopotamian floodplain (Figure 18.1) is mainly structured by channel processes, including the formation of levees, meanders, scrollbars, oxbow lakes, crevasse splays, distributary channels, inter-distributary bays, and marshes. Moreover, several human-made features also organise and shape this landscape, such as canals and both modern and ancient settlements on scales from villages to cities (Verhoeven 1998; Wilkinson 2003; Yacoub 2011). For this study, a variety of imagery, including CORONA and QuickBird images, and SRTM (Shuttle Radar Topographic Mission) and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) digital elevation data was investigated. We do not attempt to review all available topographic and satellite image platforms and datasets, but instead focus on some of the generic features of sites and landforms in the Mesopotamian plain and describe how they can be identified and interpreted using such imagery. We stress the physical appearance of features of interest rather than processing multispectral data for image enhancement. In part this is because such techniques are not applicable to the high-resolution panchromatic data we have used. Additionally, we find that such techniques are not always needed for the identification and interpretation of key features. The high spatial resolution of both panchromatic datasets and digital topography is the critical parameter.

Digital topography (srtm and aster)

SRTM data were acquired via a radar system on board the Space Shuttle *Endeavor* in 2000, with the objective of producing elevation data for most parts of the globe. Imagery is available for Iraq with the standard 90 m pixel size, and it can be freely downloaded online from the Consortium for Global Agricultural Research (CGIAR) website. The CGIAR website contains 5 x 5 degree tiles made from the original 1 x 1 degree data, which is available from the United States Geological Service (USGS).

ASTER data has a pixel size of 15 m, and include data in 14 spectral bands, from the visible to the thermal infrared wavelengths. A stereo viewing capability has made it possible to create digital elevation models, which are now also available (referred to as ASTER GDEM).

Most geomorphologic features of the palaeochannels and archaeological sites in the Mesopotamian floodplain have a relatively high topographic elevation with respect to the surrounding area; this phenomenon can make these features easy to identify in both SRTM and ASTER data (Altaweel 2005; Hritz and Wilkinson 2006). Digital elevation data may be more useful than either panchromatic or multispectral satellite imagery, even if the spatial resolution is lower, because the crucial element in identifying these features is the relative height. Conversely, some palaeochannels and archaeological mounds with low elevation and small dimensions cannot be identified by SRTM or ASTER because their resolution and accuracy are not sufficient to recognise certain features (Rexer and Hritz 2014). In this paper, we will therefore demonstrate how to use the visual expression of objects that are visible in QuickBird and CORONA satellite images to recognise palaeochannels and archaeological sites, as well as how to recognise these features by examining SRTM and ASTER topography.

SRTM and ASTER data can be used to examine and quantify topographic values of the surface features in several ways, such as by taking cross-profiles of river levees (Hritz and Wilkinson 2006). Simple topographic maps can be sufficient to show raised levee systems where such features are not clear on multispectral or panchromatic satellite imagery. In practice, not all ancient rivers are detectable in the topography data, for example, in the case of levees that have been destroyed by cultivation or quarrying, or where it has

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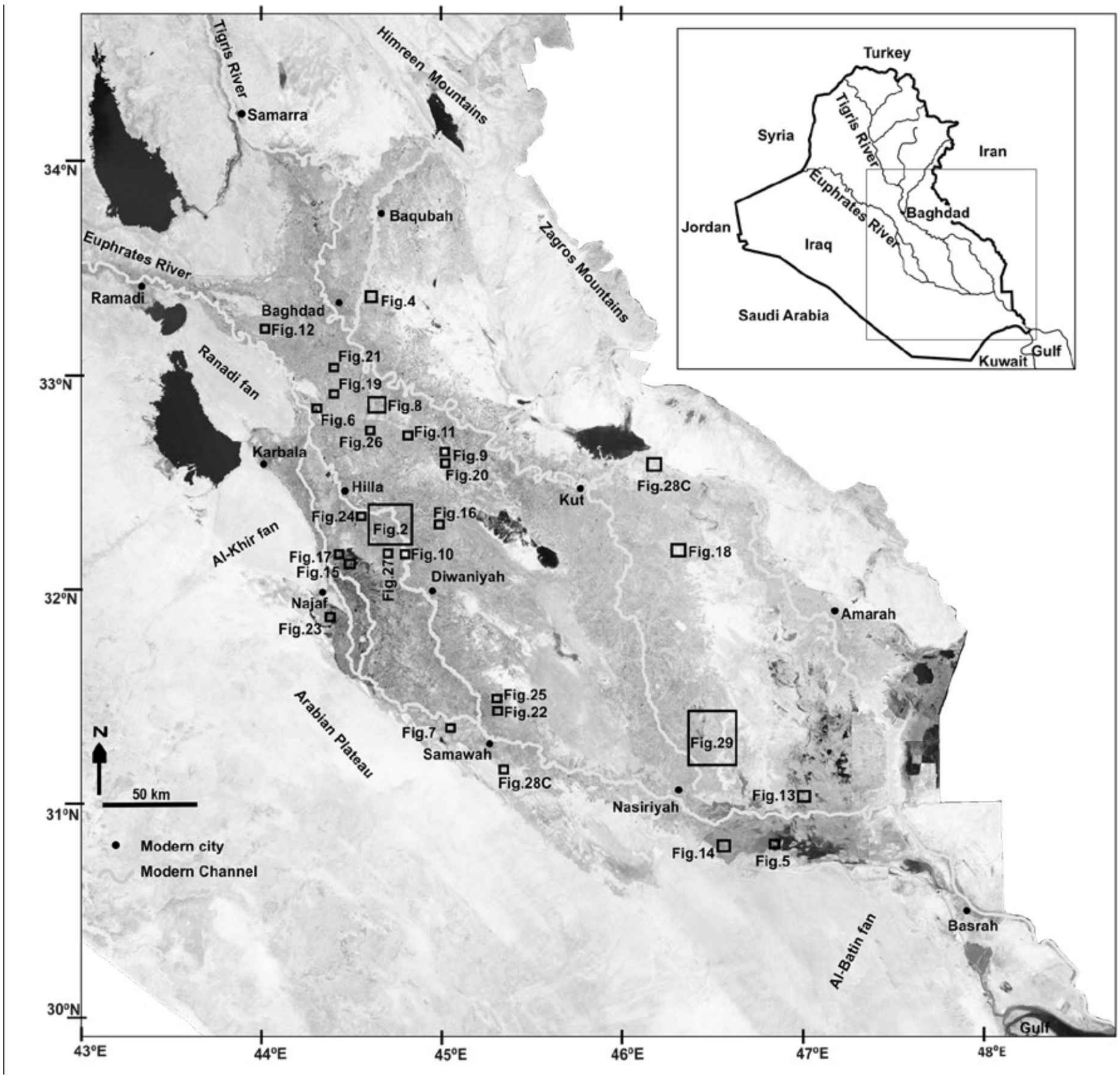

Figure 18.1. Location map of the study area, highlighting major modern river channels.

a relatively low relief with respect to the surrounding area. Standard GIS packages are able to present and process SRTM and ASTER data, with colour scale manipulation and artificial shading among the tools routinely employed to assist in the identification of levees and site features.

Corona imagery

CORONA images were derived from a United States intelligence programme. They were used from 1959 to 1972 and then declassified by the American Government in 1995. The data have been publicly available since 1998. These images can be searched and ordered via the Internet through the United States Geological Survey website or downloaded from the Arkansas University website. CORONA images are particularly useful for the reconstruction of ancient landscapes because they provide a valuable archival record of many surface features that have since been destroyed by urban development or large-scale agricultural development projects. As the original platform was high-resolution photography the images can be considered as panchromatic (greyscale) data.

Many natural surface features can be clearly identified in CORONA images because of the high spatial resolution of the imagery. The best ground resolution for the different CORONA missions is from 13 to 2 m (Ur 2013). Examples of these surface features include river scrolls and crevasse splays. Levees and archaeological sites can also be identified by the clear shadow they cast because of their relatively high elevation in relation to the surrounding area (Ur 2013). In fact, analysis of CORONA images has revealed several ancient river channels that were identified using other examined images.

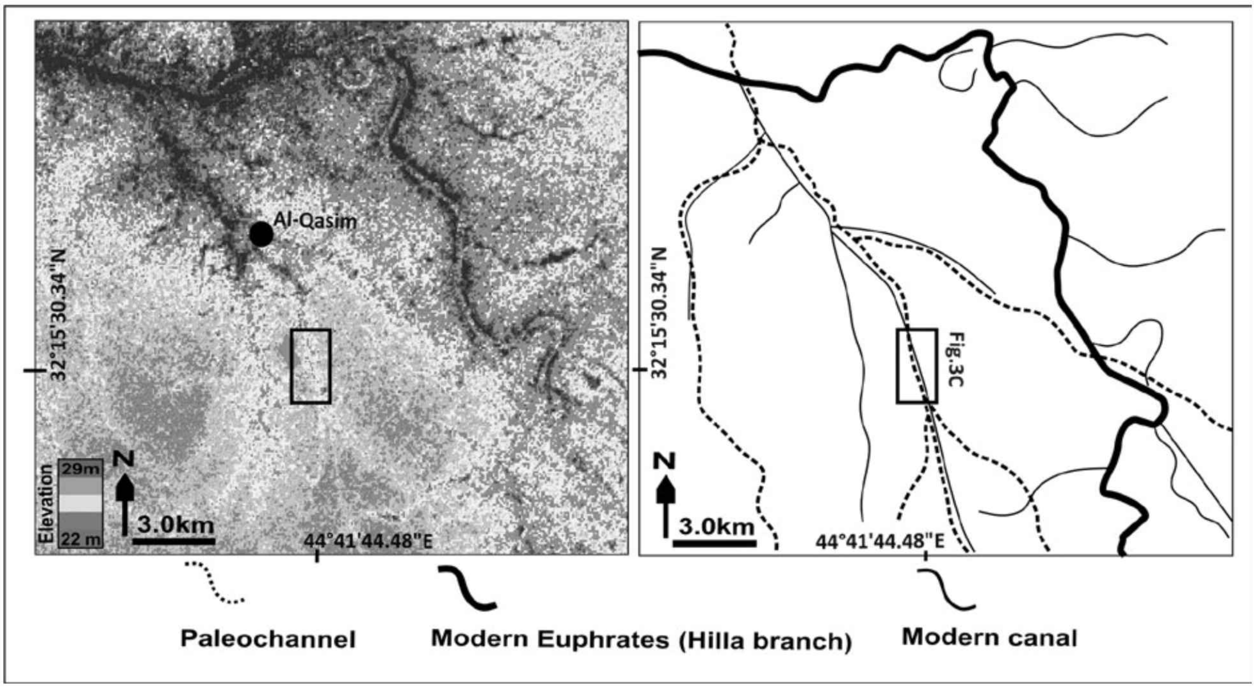

Figure 18.2. Example of elevated topography associated with a palaeochannel from an area to the south of Hilla, as it appears in SRTM data.

Quickbird imagery

DigitalGlobe is a commercial company founded in 1994 that provides high-resolution satellite images to governments and to companies such as Google. In 2009 it started to sell QuickBird satellite images to the public. Imagery is very high resolution: 61 cm for panchromatic data and 2.44–1.61 m for multispectral data. In 2007, the Iraqi Government purchased QuickBird images from 2006 for the whole of Iraq with resolutions of 0.6 m and with natural colour; these images were used in the present study. QuickBird imagery has proven to be useful in both verifying results and locating potential geomorphologic features that cannot be easily distinguished using other satellite data. Note that images derived from QuickBird (and other sources) and the GoogleEarth platform are subject to copyright arrangements.

Groundtruthing

Fieldwork for the specific study that is discussed in this paper was undertaken during February and March 2013. General observations were made at several locations, the main purpose of which was to ensure that there was agreement between what was identified in the remote-sensing work and what existed on the ground. We stress the importance of fieldwork, which should be used jointly with remote sensing studies. Fieldwork can permit 'groundtruthing' of observations made initially from satellite imagery and digital elevation models, and allows the collection of samples for dating and other analytical techniques. Alternatively, re-examination of imagery after fieldwork allows a regional-scale perspective on local features of interest identified in the field. However, in some cases, geomorphologic surface features such as ancient crevasse splays cannot be identified in the field although they are recognisable in imagery.

Useful characteristics

Recognising palaeochannels and archaeological site features and observing the differences between these features and their backgrounds involves a comparison of different features based on one or more of the visual elements of height, tone, texture, pattern, shape, shadow, size, and situation (Joseph 2005; Lillesand *et al.* 2008). Visual interpretation of QuickBird and CORONA images using these elements is the best way to identify these features, especially when SRTM and ASTER data analysis does not work, because of scale (resolution) issues.

Relative height

Relatively height refers to the difference amongst several features. As noted above, the tendency of both natural and human landforms to have relative height differences means that digital topography can be used for their identification and interpretation. SRTM (Figures 18.2 and 18.3) and ASTER (Figure 18.3) data

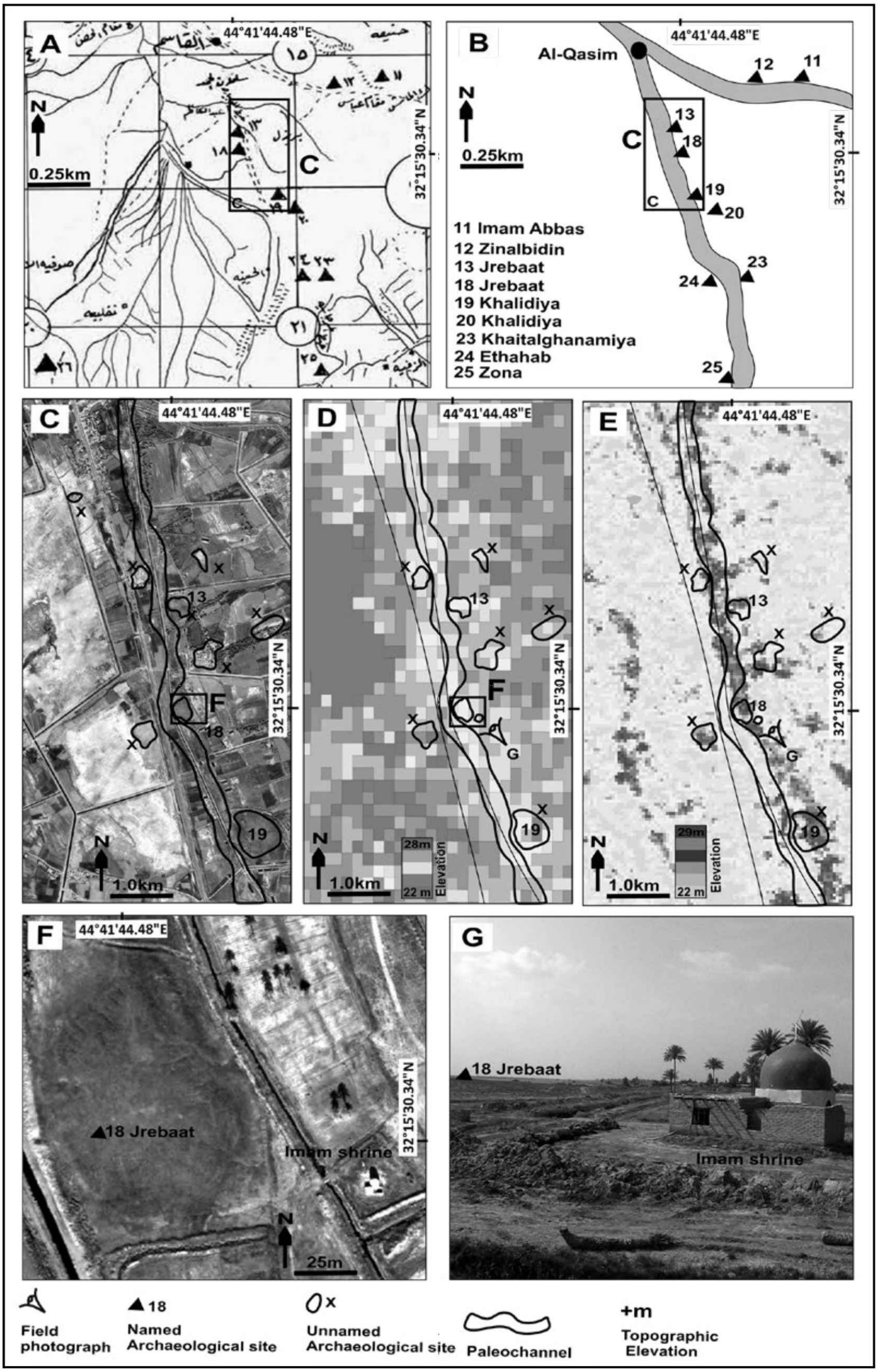

Figure 18.3. Tracing palaeochannels and archaeological sites using different datasets. (A) General Directorate of Antiquities (GDA 1970) map showing the location of archaeological sites and palaeochannels in Al-Qasim city in Babylon province. (B) Sketch showing palaeochannels and archaeological sites from Figure 18.3A. (C) QuickBird image covering part of Figure 18.3A. (D) SRTM data covering the same part of Figure 18.3A. (E) ASTER GDEM data covering the same part Figure 18.3A. (F) QuickBird image covering Jrebaat site (number 18). (G) Field photograph showing the Jrebaat site and Imam Shrine.

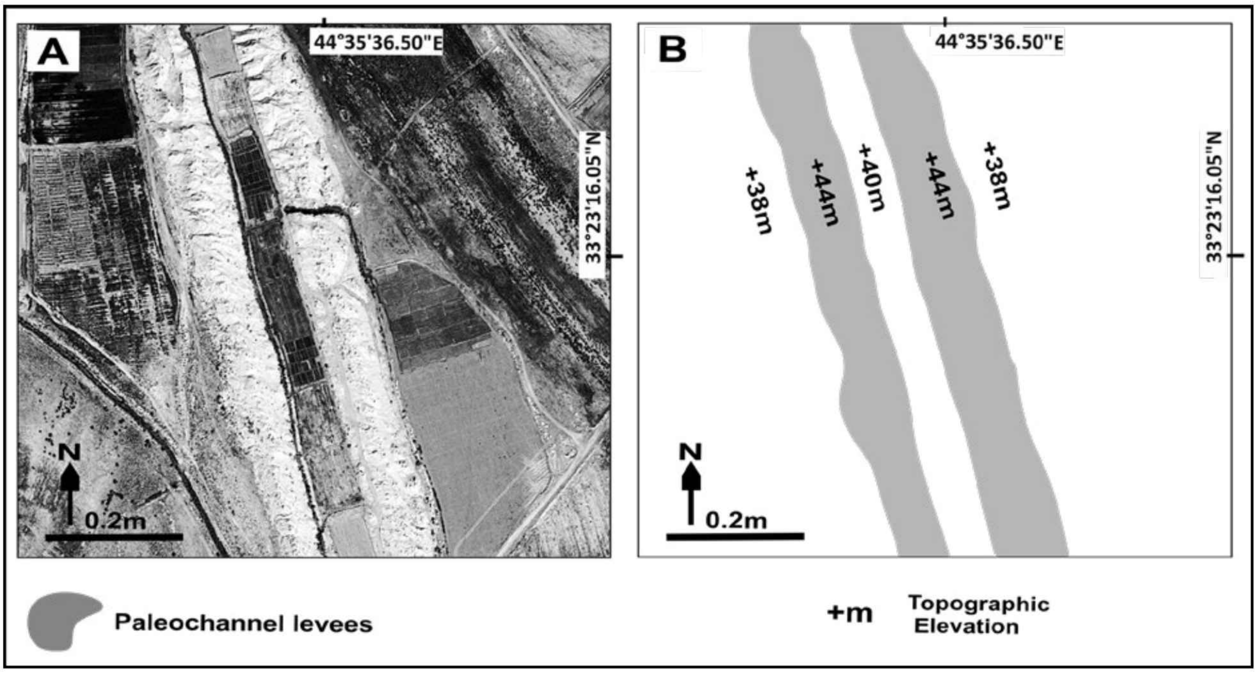

Figure 18.4. Example of a palaeochannel to the south of Baqubah City (Figure 18.1), highlighted by its tone in QuickBird imagery.

are used in the examples in conjunction with analysis of historical literature of the region and original fieldwork. The specific workflow involved initial location of palaeochannels and archaeological sites from the literature, followed by manipulation of the SRTM and ASTER data to produce maps with elevation scales that highlight the features of interest, followed by targeted fieldwork to sample material for radiocarbon dating. Note that the resolution of SRTM and ASTER data is sufficient in these examples to allow levees on distributary channels and canals to be mapped.

It is not easy to distinguish between palaeochannels and active or recently abandoned channels because both appear as ridges relatively higher than the surrounding area. However, in some cases, modern channels can be identified, because their two banks are high enough to be recognisable in relation to the channel itself. In contrast, palaeochannels appear as having one levee ('one ridge'), because the two levees have been eroded over time and the channel bottom has been filled, becoming one ridge (Figure 18.2). It has been noted in the present study that some of the Sasanian channels have a convex topographic profile i.e., two well identified levees with a channel between them. The topographic profiles of older channels (Babylonian or earlier), however, have a relatively smooth and concave profile.

Tone

Tone refers to the relative brightness and colour of objects in an image. Palaeochannel levees (Figure 18.4) and the isolated islands of archaeological mounds (Figures 18.5 and 18.6) can be recognised in QuickBird images because of differences in tone and colour compared to their surroundings. In QuickBird imagery, the essential element for distinguishing between different objects or features is the colour of the objects (Figure 18.7A), whereas in CORONA it is the brightness of the objects (Figure 18.7B). In some cases, it is difficult to recognise palaeochannels on QuickBird images (Figure 18.7A), because there is not enough relative brightness. Therefore, CORONA images (Figure 18.7B) proved better for tracing the features (Figures 18.7C and 18.7D). Additionally, in some places, the impact of modern cultivation is evident, seen in the changes of the tone of the irrigated land; archaeological mounds and levees become more recognisable as the farmer develops the area around the site.

Texture

Texture refers to the arrangement and frequency of tonal and colour variation in specific areas of an image. Palaeochannel scrollbar features (ridges and swales) are usually formed as a result of lateral migration of rivers, leading to the formation of parallel and systematic lines of ridges and swales. The present study revealed that this type of feature can occur as an associated feature of palaeochannels everywhere within the Mesopotamian floodplain. Therefore, this feature can be used as a characteristic in the identification of palaeochannels in high-resolution satellite images, such as QuickBird (Figures 18.8, 18.9, and 18.10) and CORONA (Figure 18.11A), because there is a relative

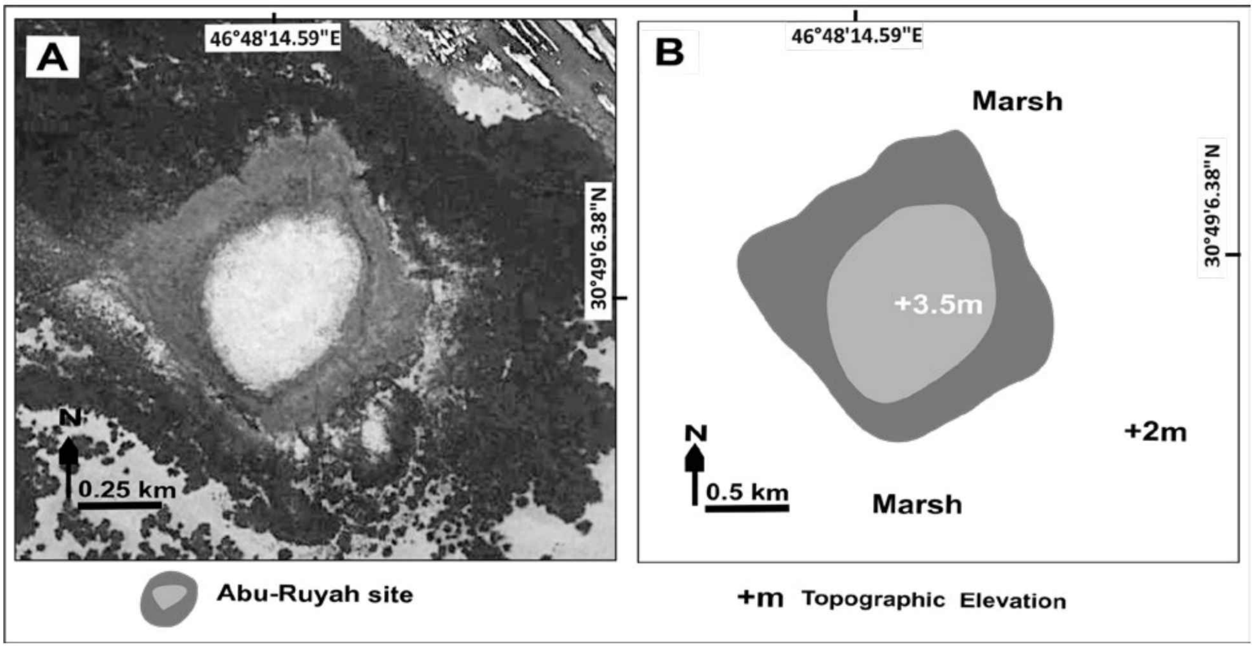

Figure 18.5. Example of an archaeological mound surrounded by marsh south of Iraq, utilising its tone in QuickBird imagery.

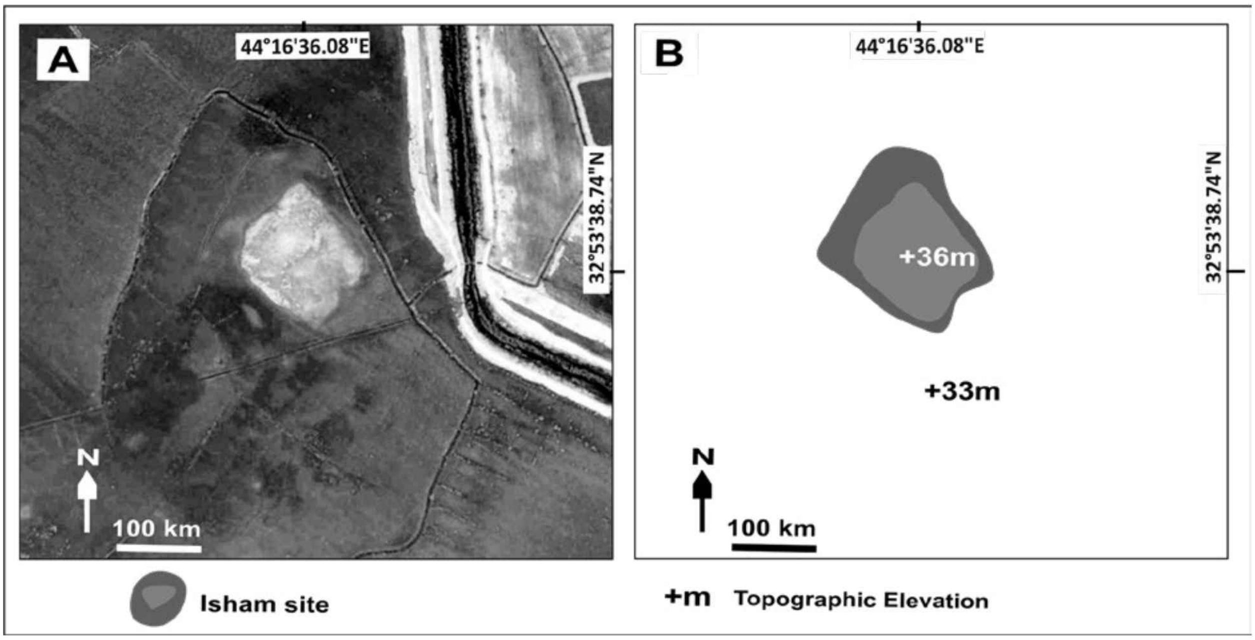

Figure 18.6. Example of an archaeological mound to the north of Hilla city, utilising its tone in QuickBird imagery.

difference in topographic elevation between ridges and swales. Furthermore, ridge sediments are coarser than swale sediments as a result of the natural sedimentation processes of meandering rivers, and therefore show up as a relative difference in tone and colour.

Such features are always associated with natural rivers (Figure 18.10), but are relatively rare in the case of human-made canals. However, sometimes such canals can meander over time so that scrollbars are formed, it will be across a smaller area in comparison with natural rivers. The scrollbars of natural channels can be difficult to detect because they were covered by more recent human-made canals, associated with natural river levees, or removed as a result of later cultivation projects. Most human settlements were built close to channel levees so, in the case of lateral river migration, new human settlements are built close

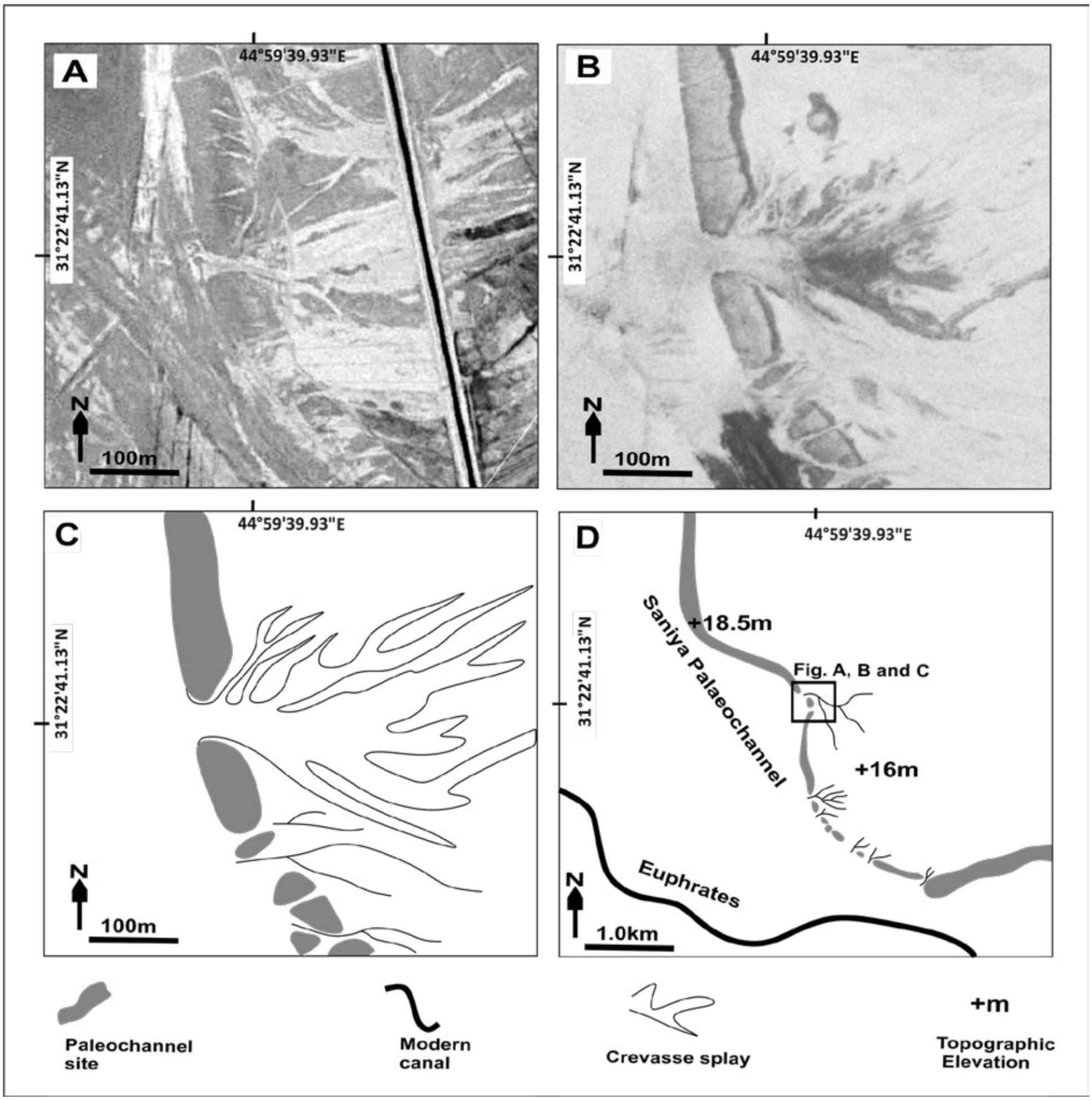

Figure 18.7. Example of a crevasse splay alongside a palaeochannel to the northeast of Samawah city, identified by the tone. (A) QuickBird image. (B) CORONA image. (C) and (D) Sketch showing tracing of the palaeochannel and crevasse splay.

to the new location of the channel. For this reason, human settlement patterns always follow the shape of these levees or scrollbars (Figure 18.10).

Pattern

Pattern refers to the spatial arrangement of features by repetition of similar tones, colours or textures. Many archaeological mounds have natural radial drainage (Figure 18.12) as a result of rain water running over the mound surface, which, over time, can become wider and longer and can easily be seen in QuickBird images, giving a good indication of the existence of archaeological mounds. However, the size of these drainages or grooves clearly reflects how the site has been affected by erosion. It can be seen that the site is wider and higher as the grooves become wider and deeper. Consequently, the size of these drainages may give an idea about the height of the site i.e., the greater the grooves, the higher the mound.

There are several mounds located in marshland areas, in the southern region of the Mesopotamian floodplain (Figures 18.13 and 18.14) that have been surrounded and partially covered by water. Most of these mounds are archaeological sites and were identified after

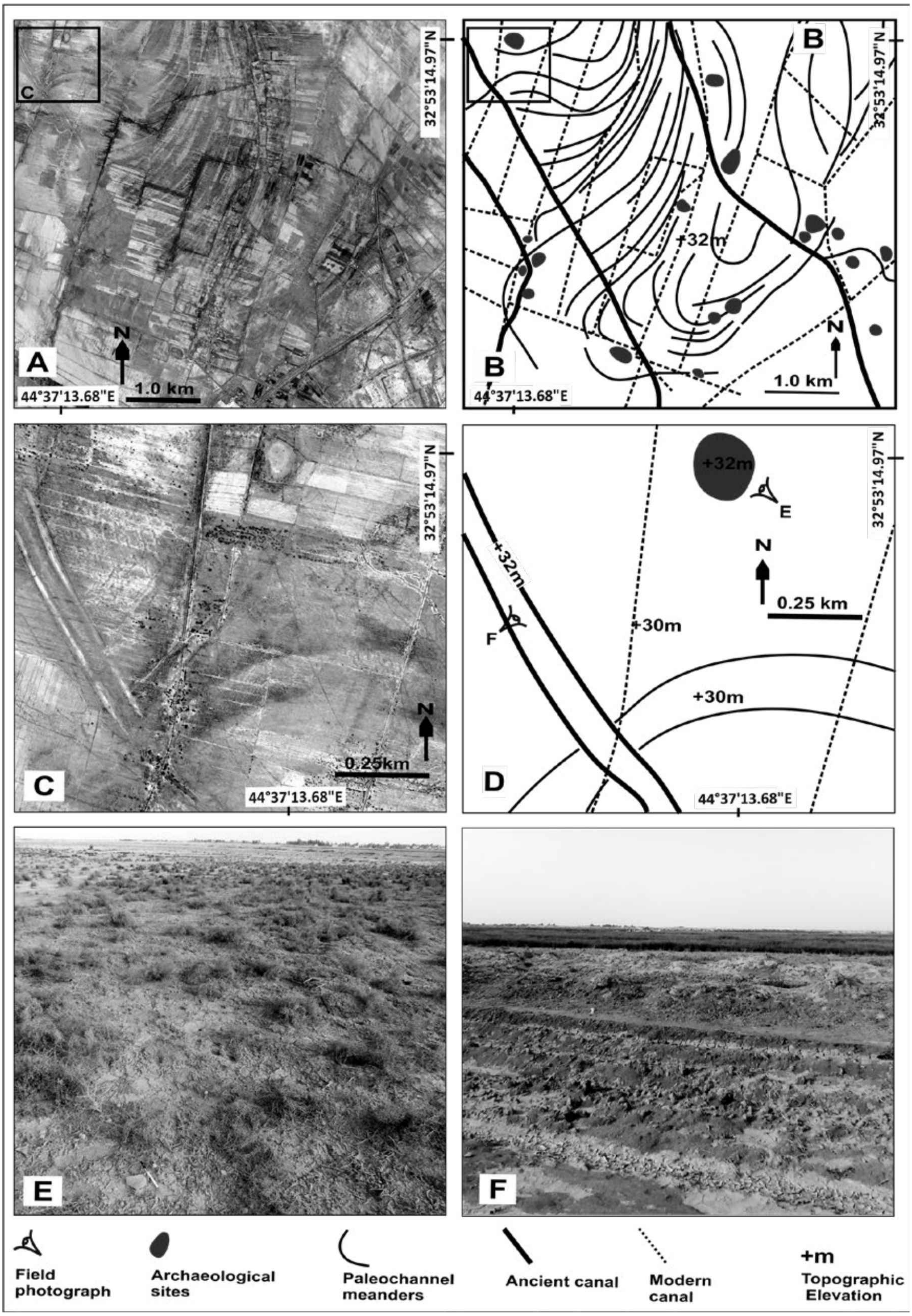

Figure 18.8. Recognition of palaeochannels and archaeological sites according to their texture in QuickBird images. (A) QuickBird image showing palaeochannel and archaeological sites located to the south of Baghdad. (B) Sketch showing the identified palaeochannel and archaeological sites of the image in (A). (C) QuickBird image showing the palaeochannel and an archaeological site in part of the image in (A). (D) Sketch showing the identified palaeochannel and archaeological sites of the image in (C). (E) Field photograph showing site of the image in (C). (F) Field photograph showing Sasanian canal visible in image (C).

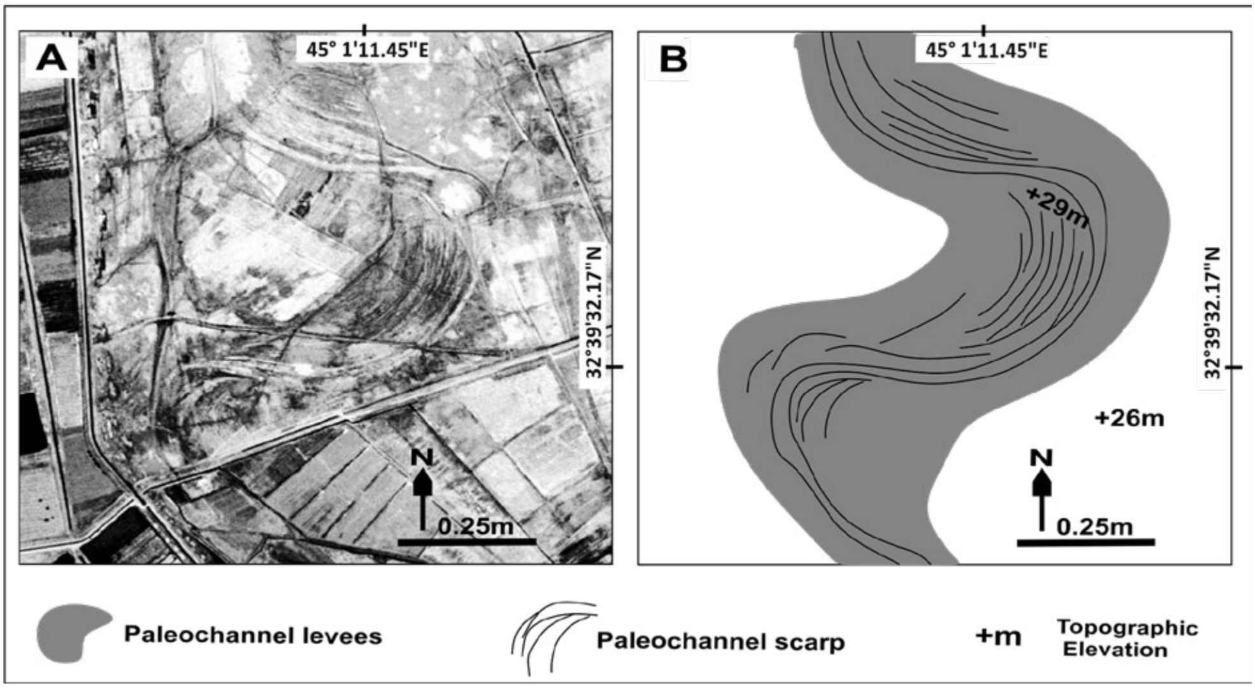

Figure 18.9. Recognition of palaeochannel and archaeological sites according to their texture. (A) QuickBird images showing palaeochannel meanders north of Kut City. (B) Sketch showing the identified palaeochannel meanders.

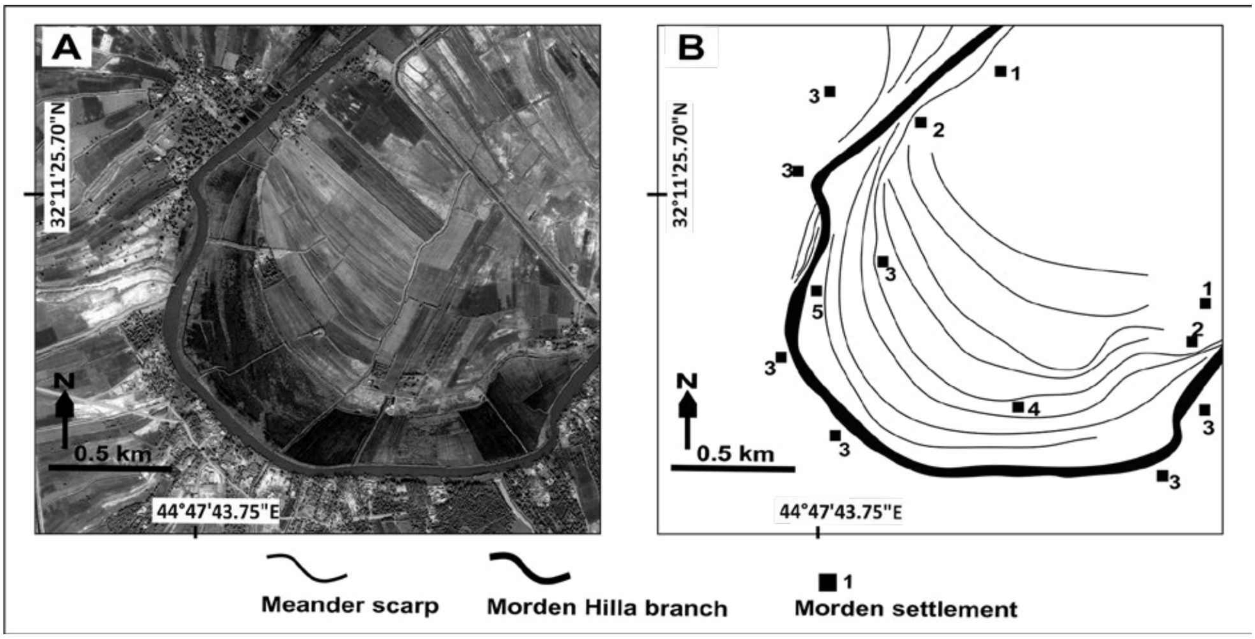

Figure 18.10. Recognition of palaeochannel meander scarps by their texture. (A) QuickBird images showing modern river meanders of the Hilla, north of Diwaniya city. (B) Sketch showing the identified meander lines and the relative ages of the houses (numbered); the oldest house was built close to the oldest meander line.

the southern marshes dried up in the 1990s (Ur and Hamdani 2014; see also chapters by Hritz, Darweesh and Pournelle; and Rey and LeCompte, this volume). Some of these mounds have recently been used as a base to build human settlements because of the lower risk of flooding or because it is the only dry land in the marsh area. These mounds can be seen clearly in QuickBird images but cannot be identified by SRTM and ASTER because of their low elevations (generally less than 2 m in relation to the surrounding marshes). It is

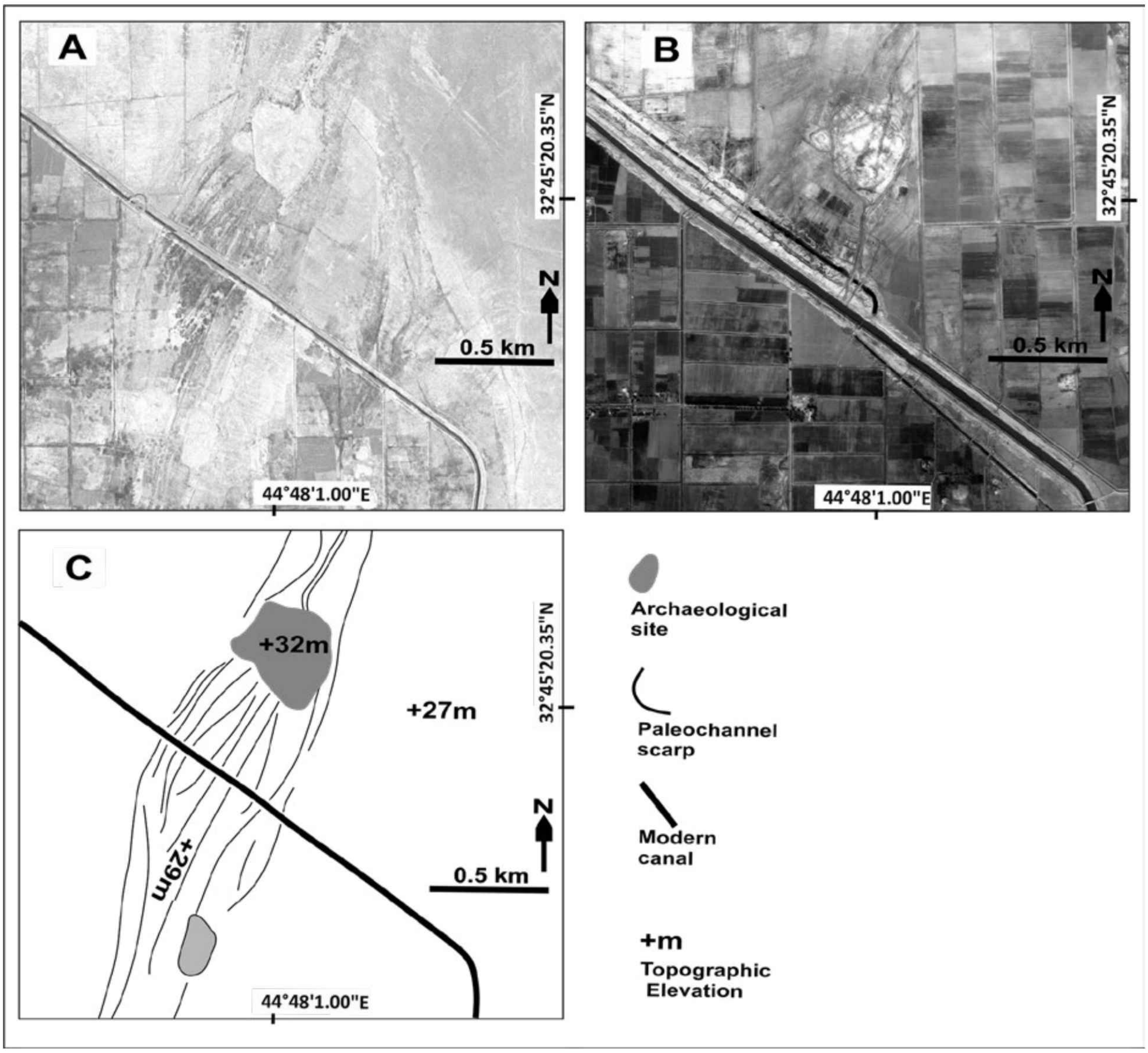

Figure 18.11. Recognition of palaeochannel meander scarps according to their texture. (A) CORONA images showing palaeochannels and archaeological sites, west of Hilla city (B) QuickBird image for the same area; note it is difficult to see the palaeochannel scarp. (C) Sketch showing the identified palaeochannel and archaeological site.

worth highlighting the fact that most of these mounds are characterised by radial features, 'linear hollows,' which are good indications of existing archaeological sites in the marsh (Figure 18.15; see Stone, this volume). According to Pournelle (2003) and Ur and Hamdani (2014), these features are the result of a combination of boat and buffalo traffic in and out of the marshes; they are preserved as soil and vegetation marks, which result from the micro-topography and variations in organic content and hydration levels compared with their surroundings. These features have also been recorded in Northern Mesopotamia and interpreted as the remains of tracks that were used to reach fields and outlying pastures (Wilkinson 1993). However, a limited number of cases have been observed in the present study where some of these features look like channels, i.e., there is water running between two banks and connected to a modern channel.

Shape

Shape refers to the general form, outline, or structure of individual objects. There are several common shapes for archaeological sites that can be used as key indicators, such as the geometrical shape of building foundations (Figures 18.16 and 18.17), the division of mounds into two parts by a palaeochannel (Figure 18.18), and the deviation of modern canals where they encounter a mound (Figure 18.19). Generally, the most common shapes of archaeological mounds visible in the imagery are elongated ellipsoid shapes, almost always arranged with the longer axis parallel to the associated

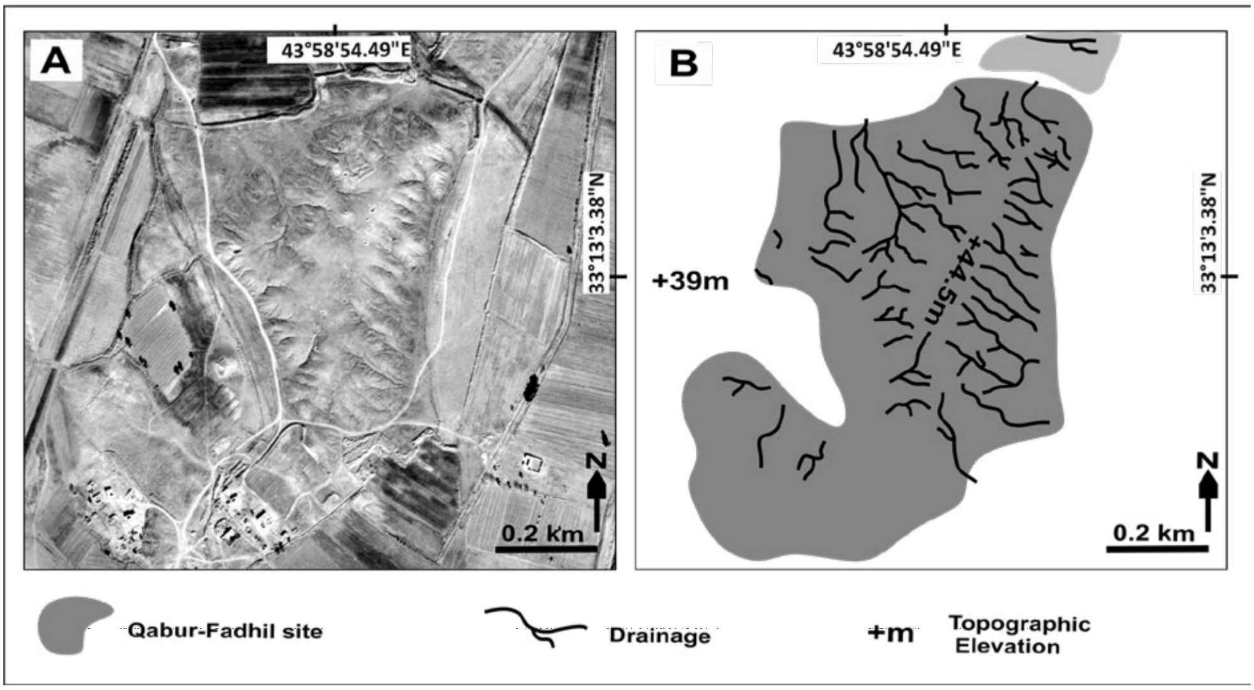

Figure 18.12. Recognition of an archaeological site according to its drainage pattern. (A) QuickBird image showing drainage pattern on a site mound, west of Baghdad (B) Sketch showing the identified drainage pattern on the archaeological site.

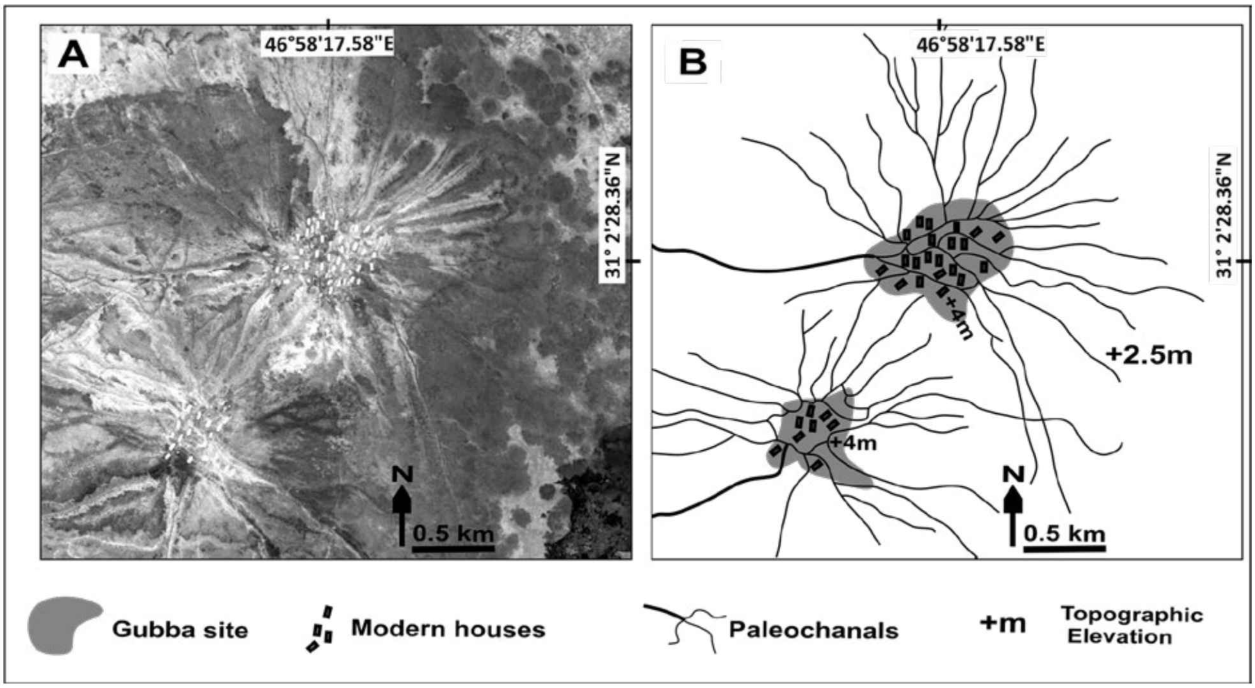

Figure 18.13. Recognition of an archaeological site according to drainage pattern around it. (A) QuickBird image showing drainage pattern around the site mounds, east of Nasiriya, formerly covered Chibayish marsh. (B) Sketch showing the identified palaeochannel and archaeological site.

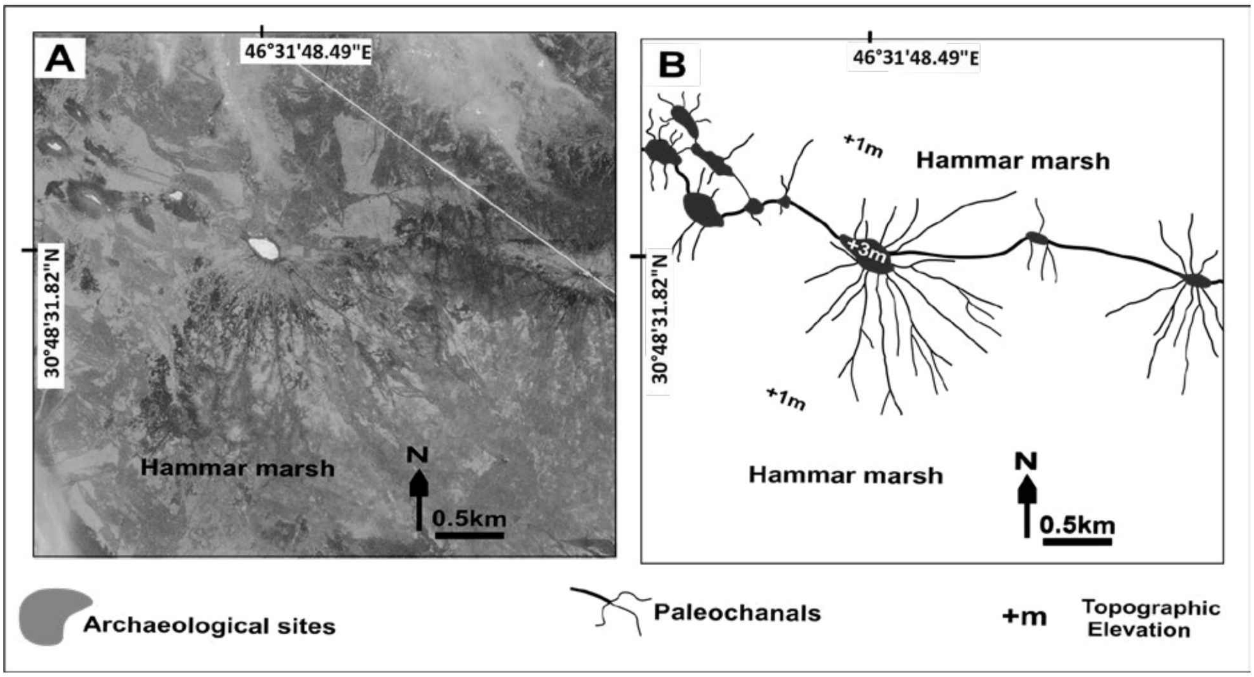

Figure 18.14. Recognition of an archaeological site according to drainage pattern around it. (A) CORONA image showing drainage pattern around the site mounds south of Nasiriya, covered by Hammar marsh. (B) Sketch showing the identified palaeochannel and archaeological sites.

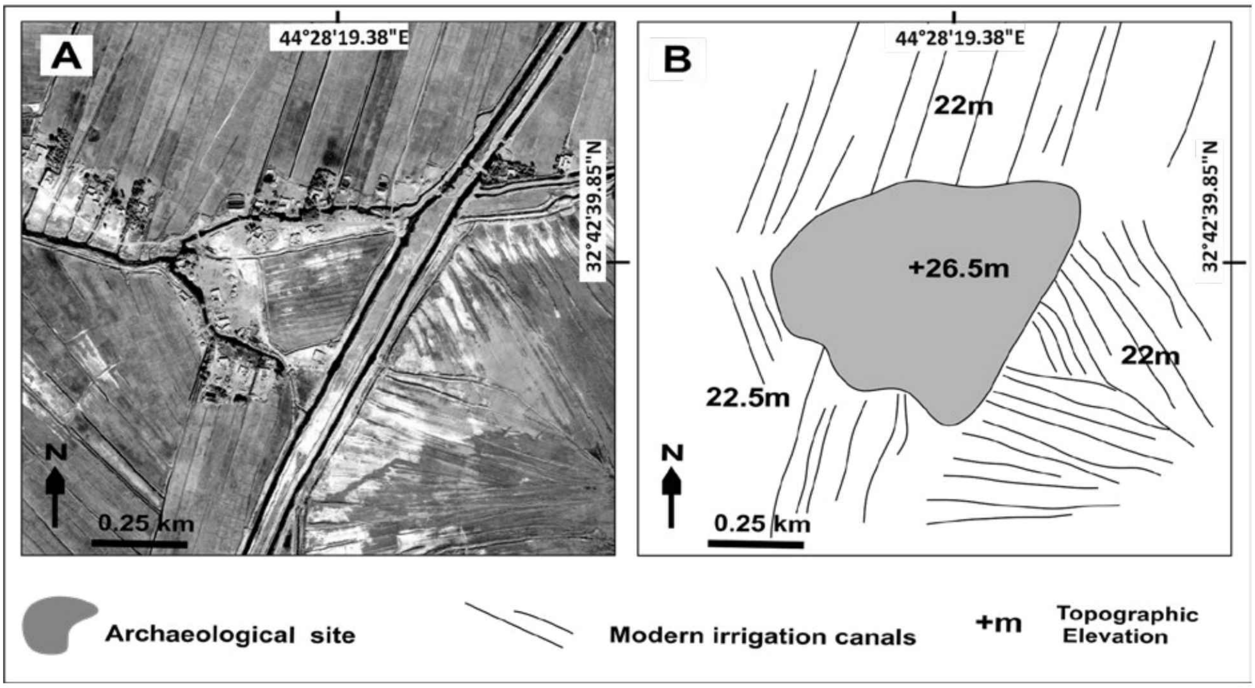

Figure 18.15. Recognition of an archaeological site according to drainage pattern around it. (A) QuickBird image showing drainage pattern around a site mound North of Najaf city. (B) Sketch showing the identified archaeological sites.

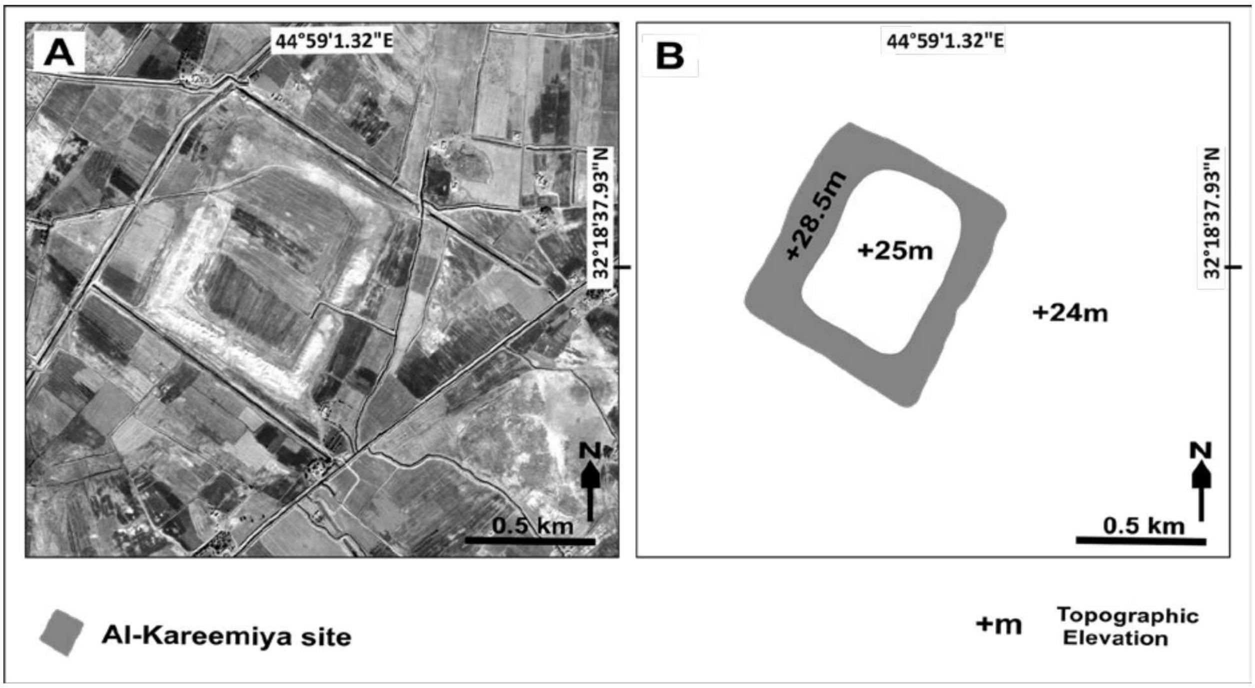

Figure 18.16. Recognition of an archaeological site according to its shape. (A) QuickBird image showing the rectangular foundation of an archaeological site southeast of Hilla city. (B) Sketch showing the identified archaeological sites.

channel (Figure 18.20). This principle might be used to predict the location of unrecognised palaeochannels. Remarkably, the shape of mounds occasionally reflects shapes of covered buildings (Figure 18.20), as the wall that surrounds a group of detached houses or large public building is also always built parallel to the associated channel (Figure 18.20).

Shadow

Shadow refers to a dark area shaped by relatively high features that block light. In fact, there are several sites that can typically be marked by shadow, particularly those sites where the remains are distinctly above the ground surface such as ziggurats, castles, and shrines. Most palaeochannels and buried archaeological sites are not sufficiently tall or appropriately shaped to create shadows, but in some cases shadows can give an indication of the height of the objects associated with the archaeological site, such as trees (Figure 18.21) and shrines or mosques (Figure 18.22).

Size

The size of features is a function of scale in an image. There are several objects that look like palaeochannels and archaeological sites; for example, unpaved roads look like palaeochannels but have a smaller size. There are two features that look like archaeological sites: seed winnowing (Figure 18.23) and modern human-made mounds (Figure 18.24). They have the same shape, colour, and elevation as an archaeological site, but not the same size.

Situation

Situation considers the relationship between other recognisable objects or features near to the target of interest. There are several objects or features that are normally associated with palaeochannels and/or archaeological sites, for example, the location of holy shrines (Figure 18.22), because the building of shrines as graves for sacred deceased people is a common Islamic custom in the Mesopotamian floodplain. Most of these shrines were built on relatively elevated areas in order to avoid flooding and groundwater. Therefore, they were built on channel levees or archaeological mounds. Most of these shrines can be recognised in QuickBird images and they can give a good indication for the identification of palaeochannels and archaeological sites. Distinct signals exist for looting; as the scatter of pits usually associated appear as pockmarks on the site (Figure 18.25). Some sites are surrounded or part-surrounded by modern urban areas (Figure 18.26), and, there are instances of small, isolated modern sites on larger ancient sites (Figure 18.27).

A natural example of situation being an important parameter is the occurrence of crevasse splays (Figure 18.28) adjacent to the main channel (Wilkinson *et al.*

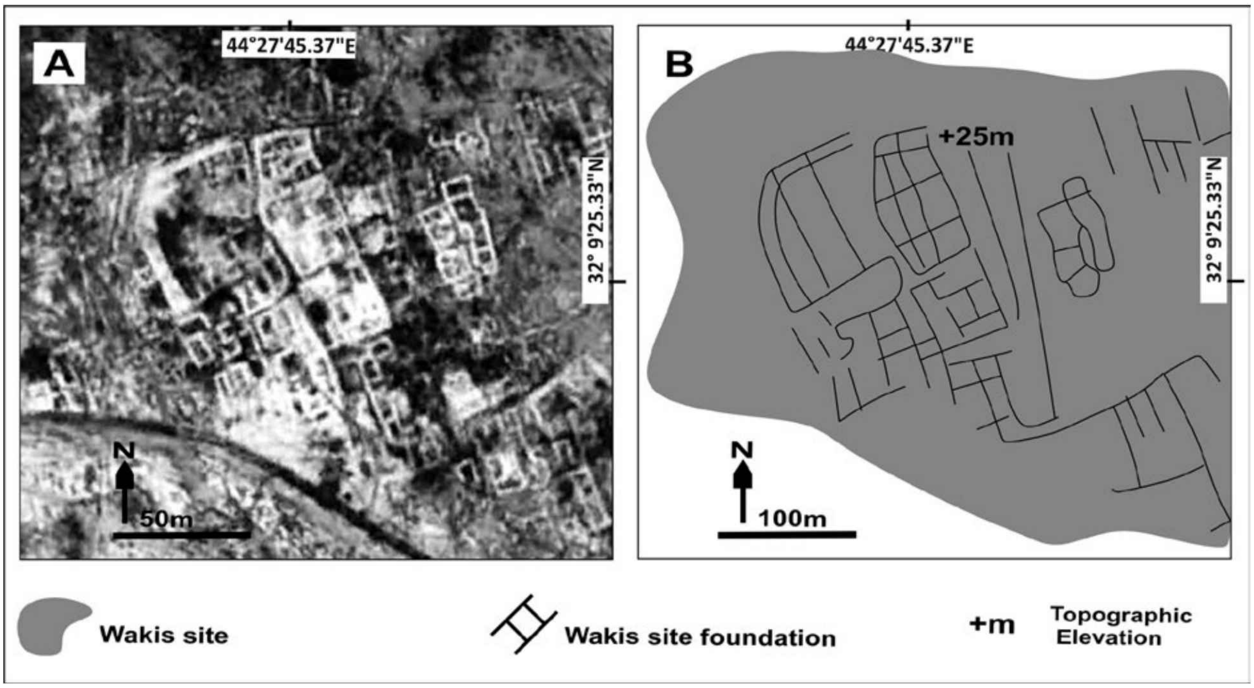

Figure 18.17. Recognition of an archaeological site according to its shape. (A) QuickBird image showing foundations of archaeological site northeast of Najaf city. (B) Sketch showing the identified archaeological site.

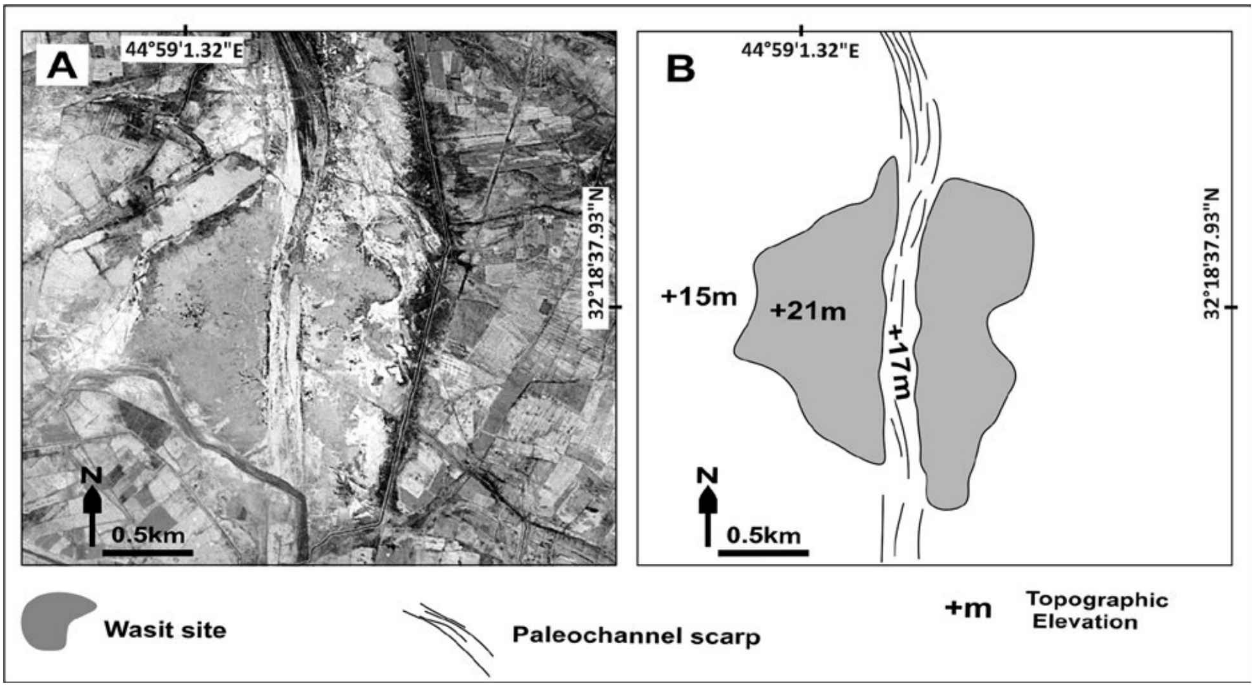

Figure 18.18. Recognition of an archaeological site according to its shape. (A) QuickBird image showing two loops of archaeological mound divided by palaeochannel southeast of Kut city. (B) Sketch showing the identified archaeological site.

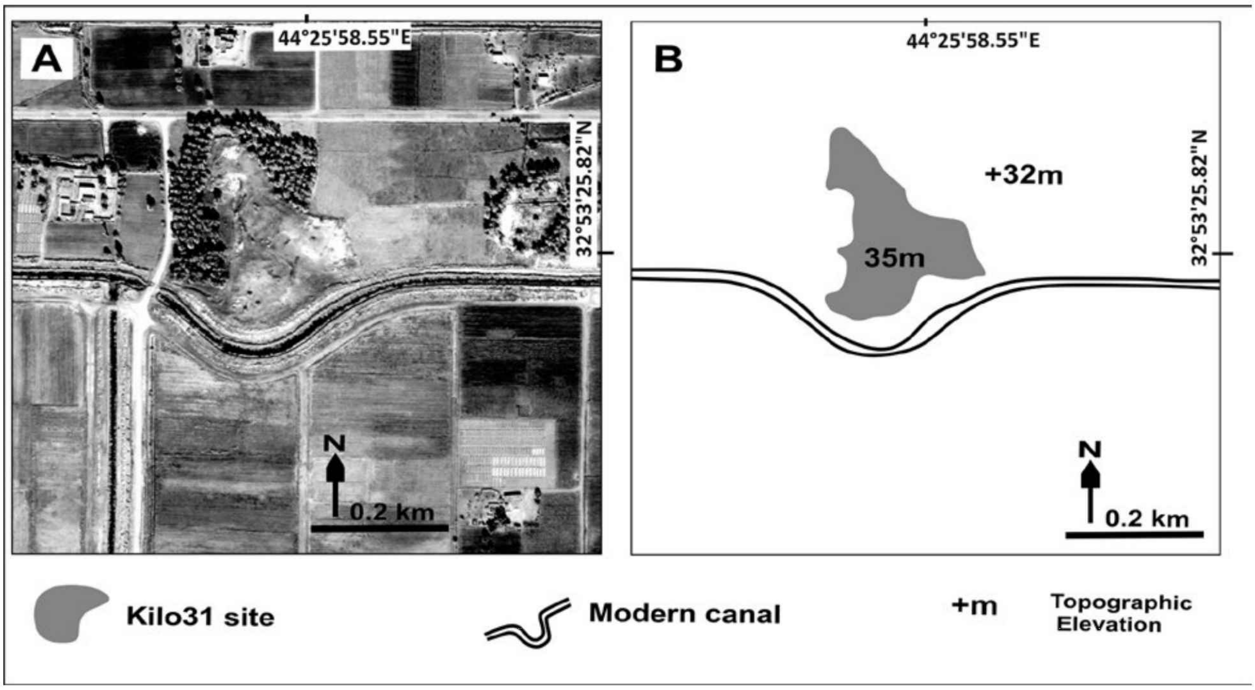

Figure 18.19. Recognition of an archaeological site according to its shape. (A) QuickBird image showing deviation of modern canal close to the archaeological mound south of Baghdad. (B) Sketch showing the identified archaeological site.

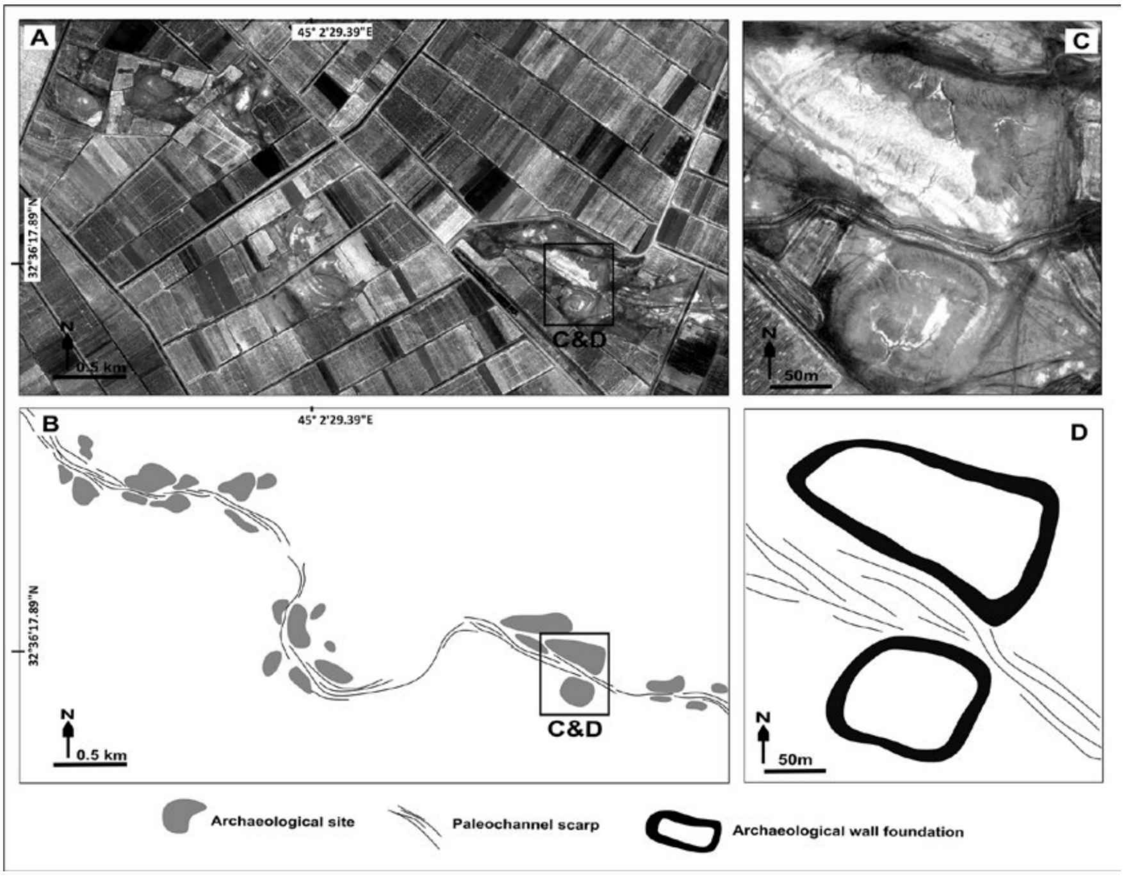

Figure 18.20. Recognising palaeochannel when the shapes of the associated sites are elongated ellipsoid shapes and arranged parallel to the channel. (A) QuickBird image showing archaeological sites associated with palaeochannel (B) Sketch showing the identified archaeological sites. (C and D) Two elongated sites reflect shape of covered building and parallel to the channel.

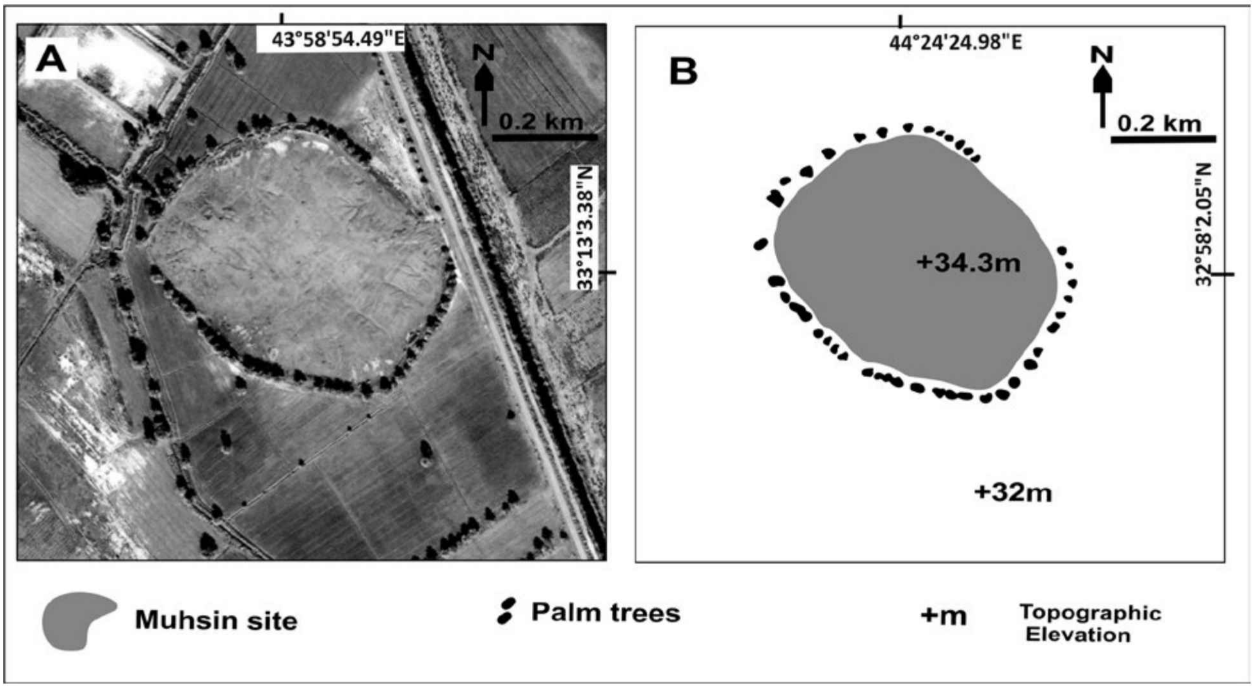

Figure 18.21. Recognition of an archaeological site according to shadow. (A) QuickBird image showing high trees around an archaeological site south of Baghdad. (B) Sketch showing the identified archaeological site.

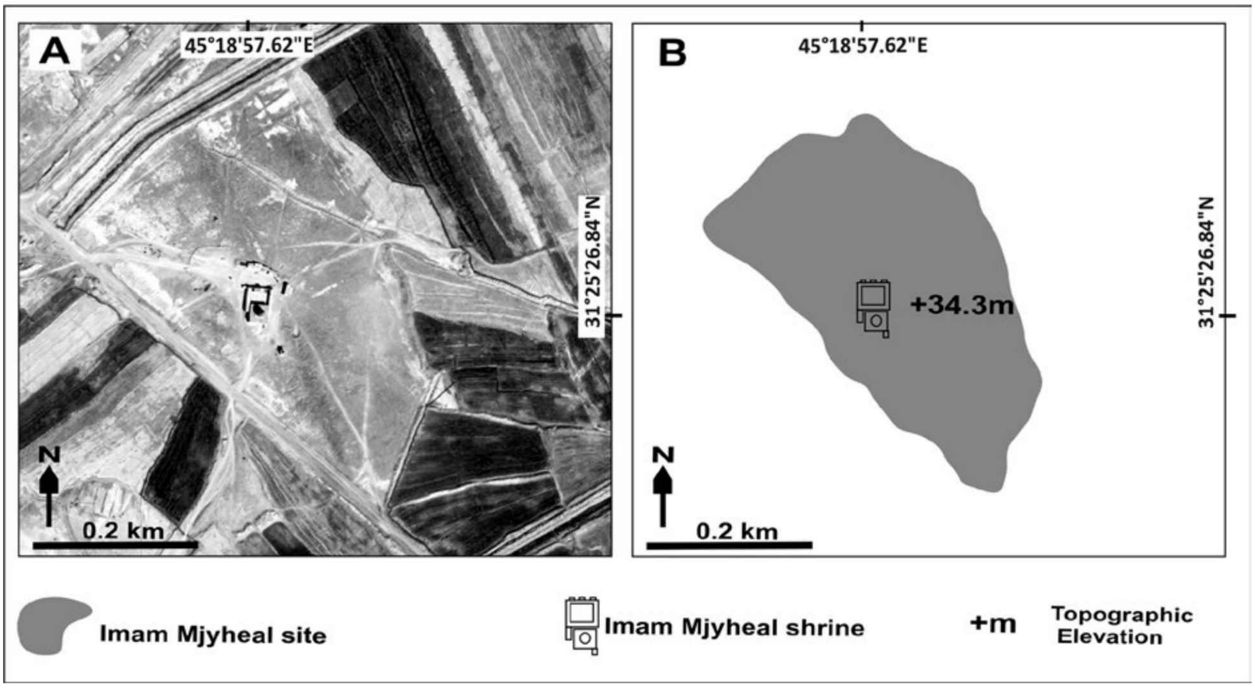

Figure 18.22. Recognition of an archaeological site according to shadow. (A) QuickBird image showing a shrine over an archaeological site south of Diwaniya city. (B) Sketch showing the identified archaeological site.

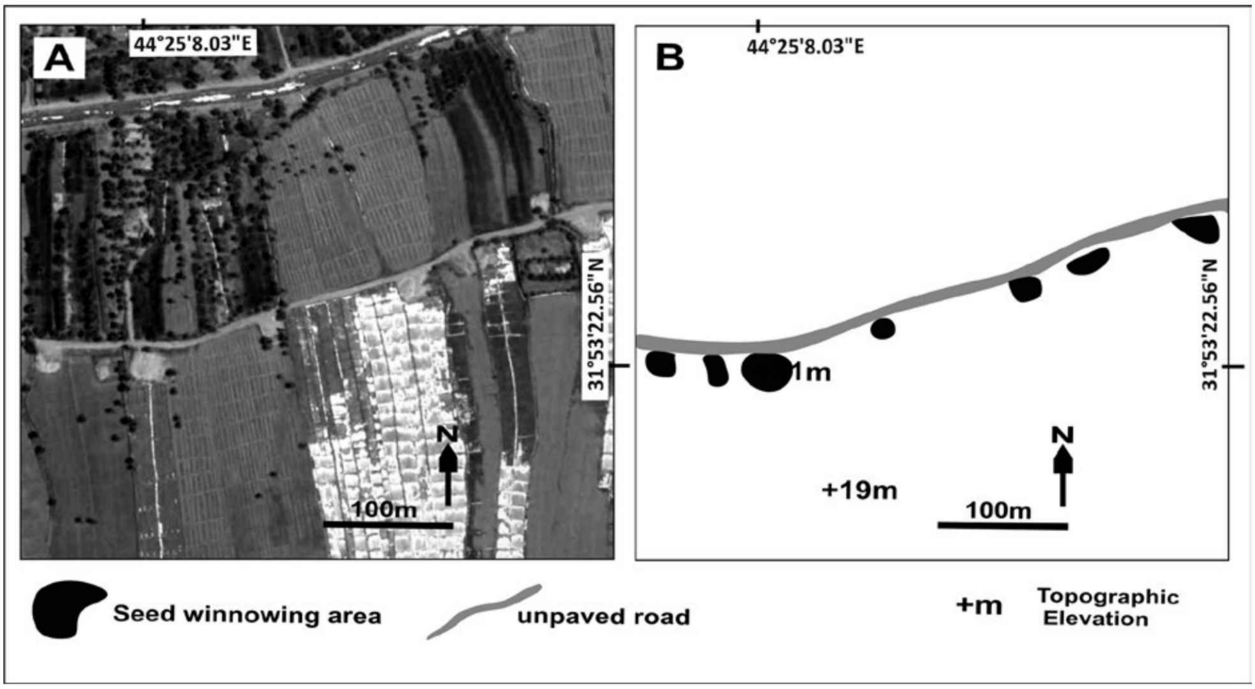

Figure 18.23. Potential pitfalls in the recognition of an archaeological site according to its size. (A) QuickBird image showing a seed winnowing area associated with an unpaved road southwest of Najaf city. It is not an archaeological site associated with a palaeochannel. (B) Sketch showing the identified features.

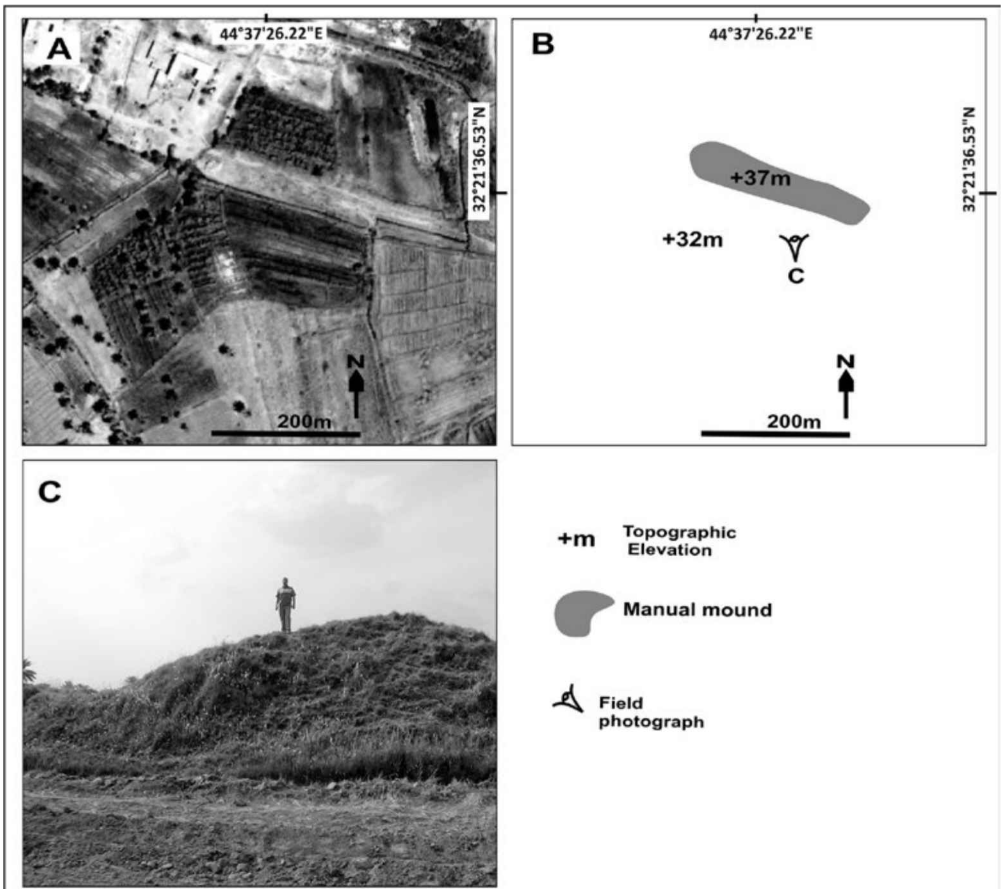

Figure 18.24. Potential pitfalls in the recognition of an archaeological site according to its size. (A) QuickBird image showing recent manually dug mound south of Hilla city. It is not an archaeological site. (B) Sketch showing the identified mound. (C) Field photograph showing the mound.

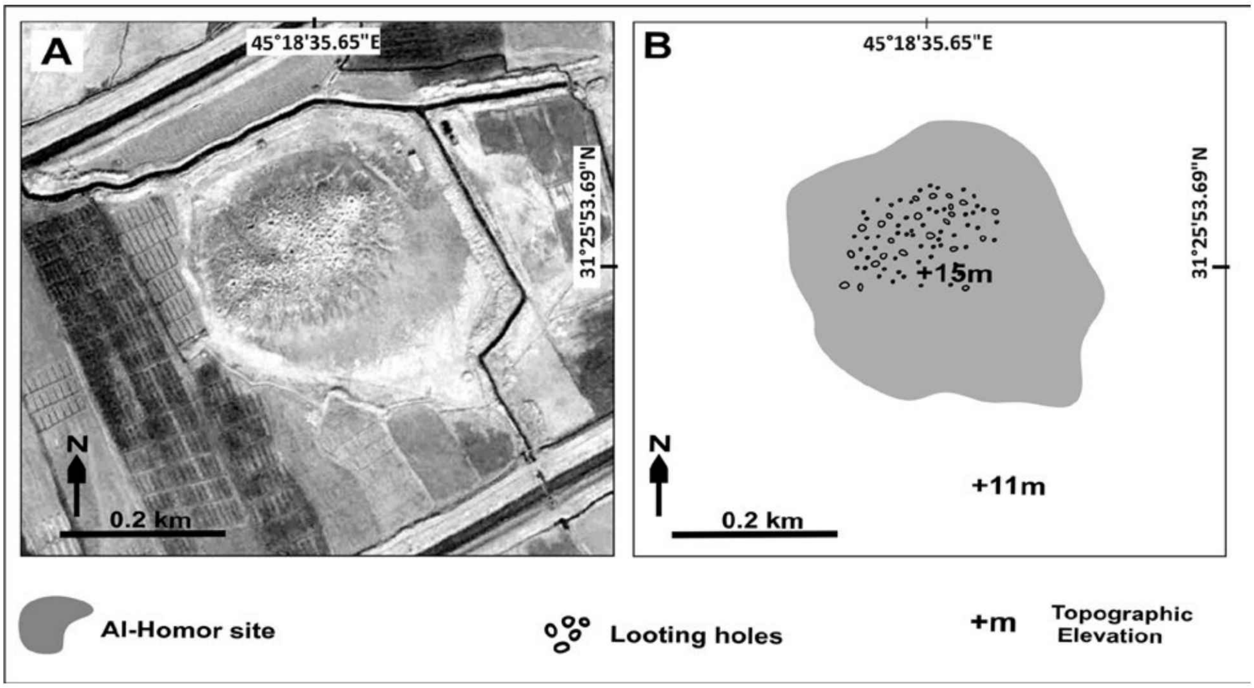

Figure 18.25. Recognition of an archaeological site according to situation. (A) QuickBird image showing looting holes on an archaeological site north of Samawah city. (B) Sketch showing the identified mound.

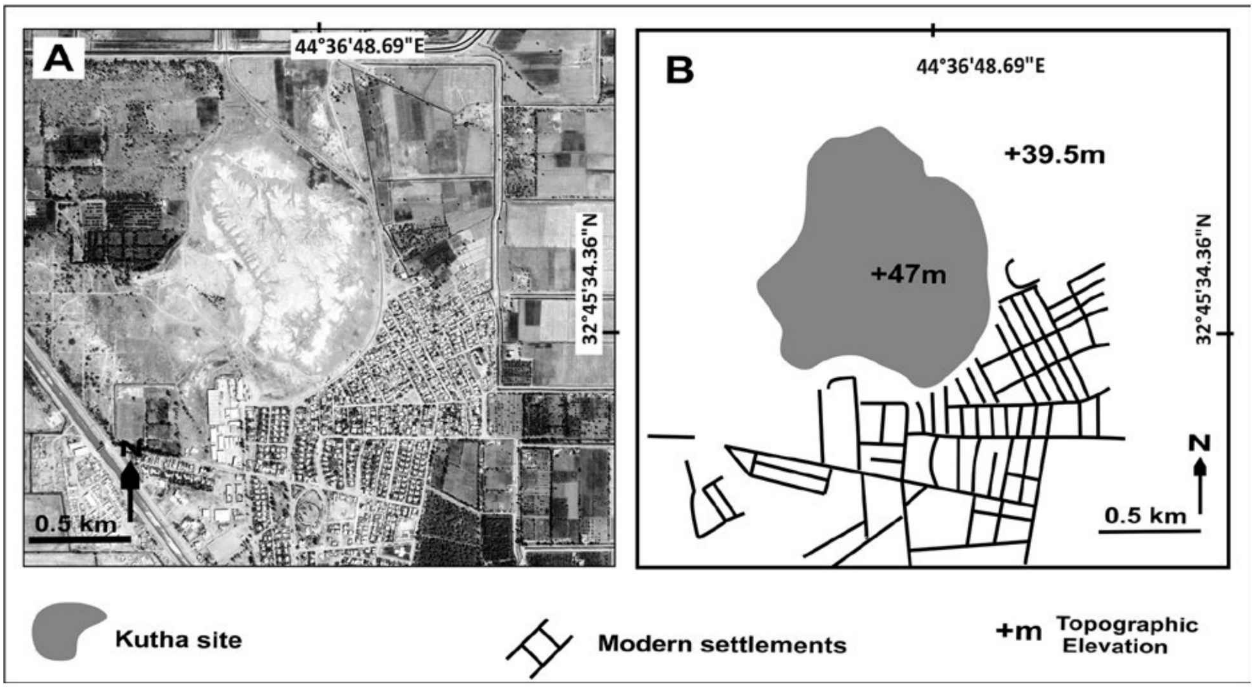

Figure 18.26. Recognition of an archaeological site according to situation. (A) QuickBird image showing modern urban development around an archaeological site northeast of Hilla city. (B) Sketch showing the identified mound.

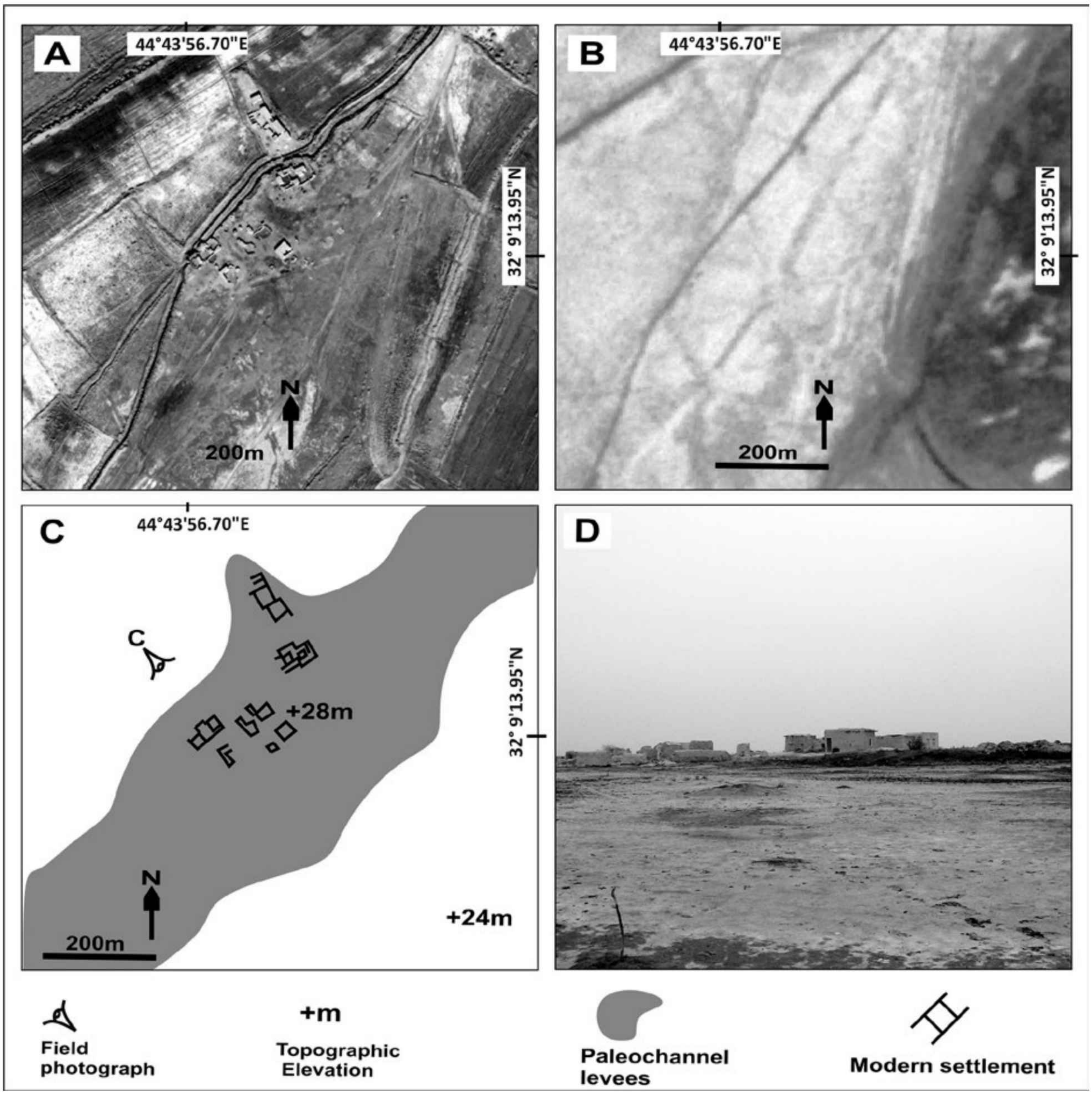

Figure 18.27. Recognition of an archaeological site according to situation. (A) QuickBird image showing modern development over palaeochannel levees north of Diwaniya city. (B) CORONA image for the same location before the houses were built. (C) Sketch showing the identified levee. (D) Field photograph showing part of this village and the palaeochannel levee.

2015). Seen in isolation, such splays may be misidentified as other kinds of channel; their relationship to the trunk stream makes their identification easier.

Case study

An area of 25 x 30 km has been selected (Figure 18.29) to illustrate the methods and criteria described in this paper. The area is located in the south of Iraq, to the north of the modern city of Nasiriya. It contains two famous archaeological sites, Lagash and Nina, both of which date from the Early Dynastic Period through the Ur III, Old Babylonian, Kassite, and Neo-Babylonian Periods. The other 12 sites date from the Parthian to Islamic Periods (Adams 1981; Hansan 1978).

What follows is an explanation of how the features described in the method section above were used to reconstruct the palaeochannel and archaeological sites in this case study. A first look at the SRTM of the case study area (Figure 18.29A) allowed us to recognise some elongated and ellipsoidal high topographic features. We interpreted these elongated features as channel levees and the ellipsoidal features as human settlements. In

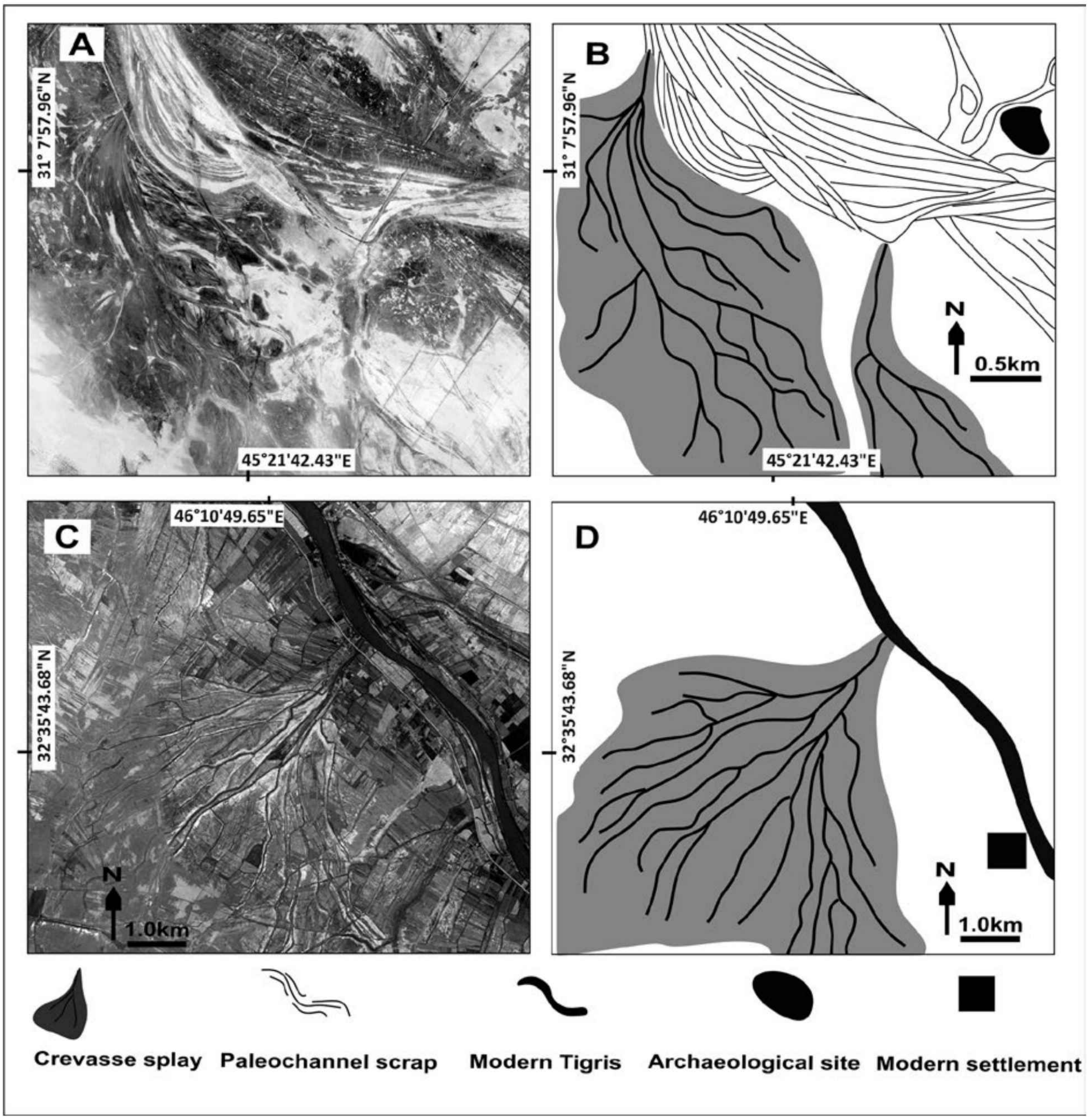

Figure 18.28. Recognition of palaeochannel according to situation. (A) QuickBird image showing crevasses splay associated with a palaeochannel west of Samawa city. (B) Sketch showing the identified features. (C) QuickBird image showing a crevasse splay associated with the modern Tigris River near Kut city. (D) Sketch showing the identified features.

order to clarify these features and find out whether they were modern or ancient, QuickBird images (Figure 18.29B) were used to trace the palaeochannels, archaeological mounds, modern channels, and marshes. The Lagash and Nina sites were large and it was easy to recognise them, but the other sites were small so some effort was required to distinguish them. Most of these sites are in a 'herringbone' alignment, indicating that they are associated with distinctive herringbone channels. The advantage of this alignment between sites and channels is that prospection in the field can be targeted to discover more sites and vice versa, i.e., looking for indications of channels around the line of the sites. Since the area is located in a relatively wet region, there is good relative tone brightness for features of relatively high elevation, i.e., sites and palaeochannels. Therefore, CORONA images were helpful. Most of the palaeochannels have well identified textures because the scrollbar features are very well preserved there.

As a result of tracing all the important features, it was found that there are two palaeochannels (known as

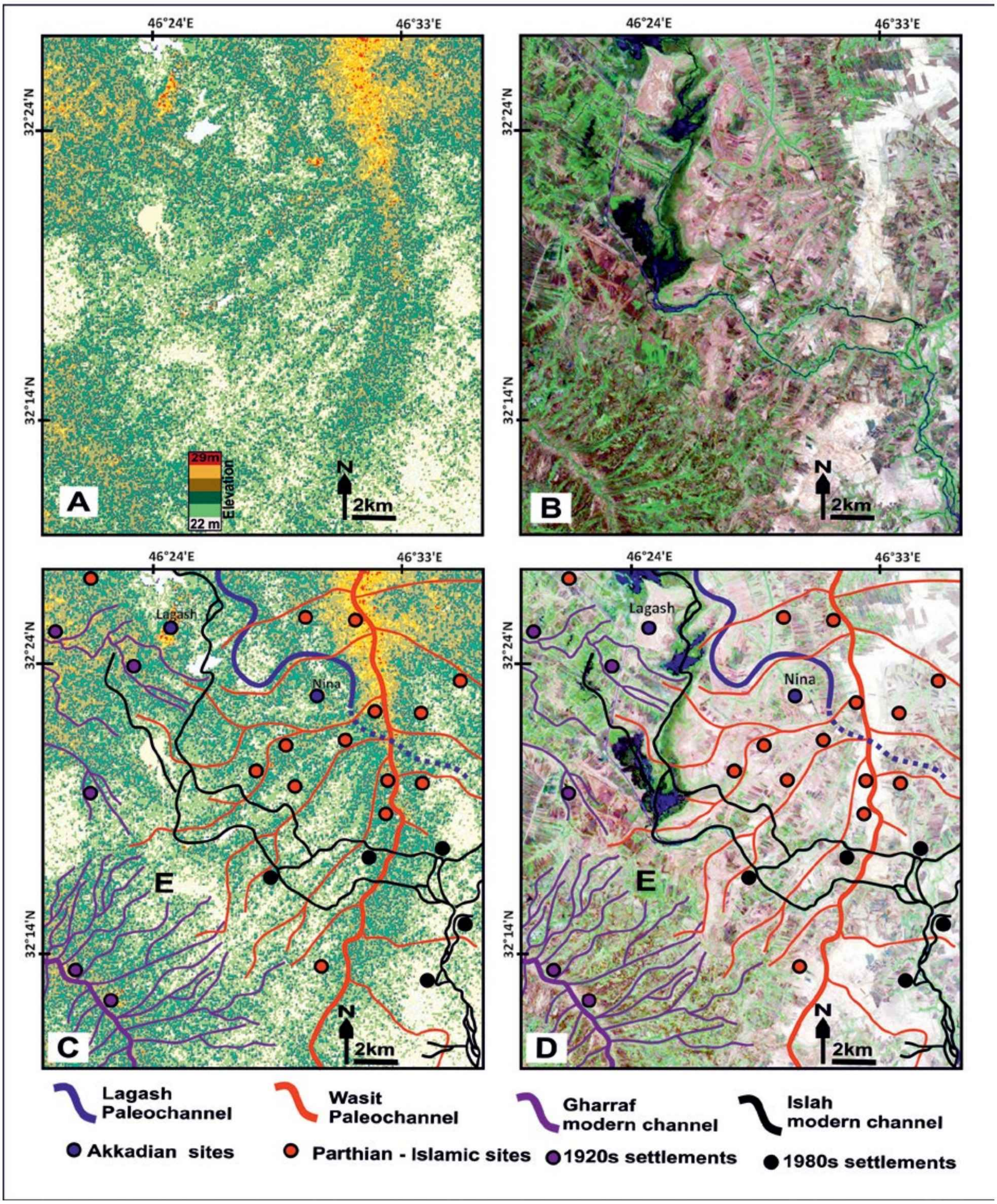

Figure 18.29. Case study showing tracing palaeochannel and archaeological sites north of Nasiriya city (see Figure 19.1). (A) SRTM data showing topographic relief of both modern and palaeochannel. (B) Landsat image for the same area. (C) and (D) tracing of the features on the SRTM and the Landsat respectively

the Lagash-Nina and Dujaila channels, associated with ancient settlements) and two modern channels (the Gharraf and the Islah channel running from the marsh) associated with modern settlements. However, a classification of the palaeochannels into a chronological order was attempted to provide a good indication of the relative age of the sites as well. Using the imagery it was possible to assess the stratigraphic relationships between the channels, since newer features clearly cut into older ones, and therefore to develop a chronological schema. The Gharraf distribution canals cut both the Lagash-Nina channel and the Dujaila channel. Additionally, the Dujaila channel cuts the Lagash-Nina channel, while the Islah channel cuts the Dujaila. Most archaeological sites associated with the Dujaila channel in this area were dated as Parthian, Sasanian, or Islamic in previous studies, such as those by Ur and Hamdani (2010). The fieldwork of the present study included taking samples from the palaeochannels for radiocarbon dating and groundtruthing of some small archaeological sites where the satellite images were unclear. The author intends to publish more results about the radiocarbon ages of this area and other areas in Southern Mesopotamia at a later date.

It is considered axiomatic that periods of active channels are closely linked to the ages of archaeological settlements and most of the identified ancient settlements were established on active channels (Adams 1981; Cole 1994). Four different periods of channels with four different settlements have been found (Figure 18.29).

The oldest palaeochannel is that associated with the sites of Lagash and Nina. The second palaeochannel is Dujaila, which is associated with the Parthian-Islamic sites. The third channel is the modern Gharraf branch and there are several modern towns associated with it. The fourth course is the Islah channel, which became active from around 1980 when the marshes started to dry up; drained water is continuing to gather in it. These results demonstrate that each channel was associated with a specific and defined period of settlement.

Conclusions

Over many millennia, humanity and nature have left their marks on the Earth in different ways, and always there are signatures for us to discover and use to interpret the past. The integration of geomorphological, geological, and archaeological data is the best method to understand the formation and evolution of the landscape of certain areas, and this is very much the case in Southern Mesopotamia where the surface is easily modified by natural and anthropogenic processes. It is important to use different types of satellite images and elevation data to form a better interpretation of surface features. However, using only remote sensing data does not produce a complete analysis, and needs support from groundtruthing, in this case through traditional fieldwork investigations. The wealth of new, high-resolution satellite imagery now becoming freely available, makes this an exciting time for archaeology, geomorphology, and neotectonic studies alike.

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